US008459520B2

(12) **United States Patent**
Giordano et al.

(10) **Patent No.: US 8,459,520 B2**

(45) **Date of Patent: Jun. 11, 2013**

(54) **SURGICAL INSTRUMENT WITH WIRELESS COMMUNICATION BETWEEN CONTROL UNIT AND REMOTE SENSOR**

(75) Inventors: **James R. Giordano**, Milford, OH (US); **Jeffrey S. Swayze**, Hamilton, OH (US); **Frederick E. Shelton, IV**, New Vienna, OH (US)

(73) Assignee: **Ethicon Endo-Surgery, Inc.**, Cincinnati, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 941 days.

(21) Appl. No.: **11/651,807**

(22) Filed: **Jan. 10, 2007**

(65) **Prior Publication Data**

US 2008/0167672 A1 Jul. 10, 2008

(51) **Int. Cl.**
A61B 17/32 (2006.01)

(52) **U.S. Cl.**
USPC **227/175.1**; 227/180.1; 227/181.1; 227/2; 227/19; 606/219; 606/50; 606/51; 606/52; 606/45; 606/46; 606/47

(58) **Field of Classification Search**
USPC 227/175.1, 180.1, 181.1, 2, 19; 606/219, 606/50–52, 45, 46–47, 159; 74/DIG. 7
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

66,052 A 6/1867 Smith
662,587 A 11/1900 Blake
951,393 A 3/1910 Hahn
2,037,727 A 4/1936 La Chapelle
2,132,295 A 10/1938 Hawkins
2,161,632 A 6/1939 Nattenheimer
2,211,117 A 8/1940 Hess
2,214,870 A 9/1940 West
2,441,096 A 5/1948 Happe
2,526,902 A 10/1950 Rublee
2,674,149 A 4/1954 Benson
2,804,848 A 9/1957 O'Farrell et al.
2,808,482 A 10/1957 Zanichkowsky et al.
2,853,074 A 9/1958 Olson

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2458946 A1 3/2003
CA 2512960 A1 1/2006

(Continued)

OTHER PUBLICATIONS

European Search Report, Application No. 08250080.2, dated Nov. 4, 2009 (7 pages).

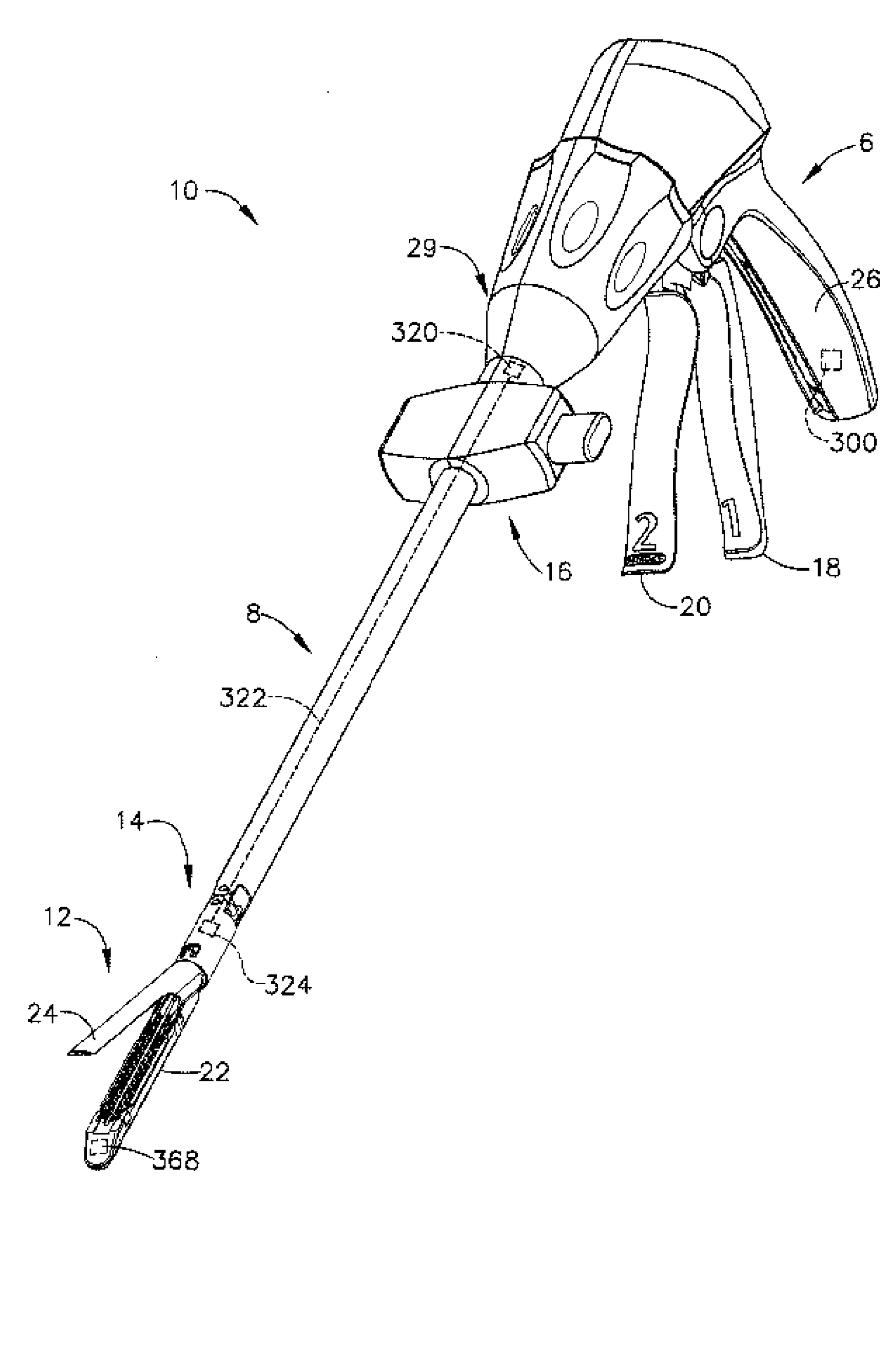
(Continued)

Primary Examiner — Brian D Nash
Assistant Examiner — Michelle Lopez

(57) **ABSTRACT**

A surgical instrument, such as an endoscopic or laparoscopic instrument. The surgical instrument may comprise an end effector comprising at least one sensor. The surgical instrument may also comprise an electrically conductive shaft having a distal end connected to the end effector wherein the sensor is electrically insulated from the shaft. The surgical instrument may also comprise a handle connected to a proximate end of the shaft. The handle may comprise a control unit electrically coupled to the shaft such that the shaft radiates signals as an antenna from the control unit to the sensor and receives radiated signals from the sensor. Other components electrically coupled to the shaft may also radiate the signals.

21 Claims, 21 Drawing Sheets



U.S. PATENT DOCUMENTS

3,032,769 A 5/1962 Palmer
3,075,062 A 1/1963 Iaccarino
3,078,465 A 2/1963 Bobrov
3,166,072 A 1/1965 Sullivan, Jr.
3,266,494 A 8/1966 Brownrigg et al.
3,269,630 A 8/1966 Fleischer
3,357,296 A 12/1967 Lefever
3,490,675 A 1/1970 Green et al.
3,551,987 A 1/1971 Wilkinson
3,598,943 A 8/1971 Barrett
3,643,851 A 2/1972 Green et al.
3,662,939 A 5/1972 Bryan
3,717,294 A 2/1973 Green
3,734,207 A 5/1973 Fishbein
3,740,994 A 6/1973 DeCarlo, Jr.
3,744,495 A 7/1973 Johnson
3,746,002 A 7/1973 Haller
3,751,902 A 8/1973 Kingsbury et al.
3,819,100 A 6/1974 Noiles et al.
3,821,919 A 7/1974 Knohl
3,885,491 A 5/1975 Curtis
3,892,228 A 7/1975 Mitsui
3,894,174 A 7/1975 Cartun
3,940,844 A 3/1976 Colby et al.
RE28,932 E 8/1976 Noiles et al.
4,060,089 A 11/1977 Noiles
4,129,059 A 12/1978 Van Eck
4,213,562 A 7/1980 Garrett et al.
4,250,436 A 2/1981 Weissman
4,261,244 A 4/1981 Becht et al.
4,272,662 A 6/1981 Simpson
4,275,813 A 6/1981 Noiles
4,289,133 A 9/1981 Rothfuss
4,305,539 A 12/1981 Korolkov et al.
4,317,451 A 3/1982 Cerwin et al.
4,321,002 A 3/1982 Froehlich
4,331,277 A 5/1982 Green
4,340,331 A 7/1982 Savino
4,347,450 A 8/1982 Colligan
4,349,028 A 9/1982 Green
4,353,371 A * 10/1982 Cosman 606/42
4,379,457 A 4/1983 Gravener et al.
4,380,312 A 4/1983 Landrus
4,383,634 A 5/1983 Green
4,396,139 A 8/1983 Hall et al.
4,402,445 A 9/1983 Green
4,408,692 A 10/1983 Siegel et al.
4,415,112 A 11/1983 Green
4,428,376 A 1/1984 Mericle
4,429,695 A 2/1984 Green
4,434,796 A 3/1984 Karapetian et al.
4,442,964 A 4/1984 Becht
4,451,743 A 5/1984 Suzuki et al.
4,454,887 A 6/1984 Krüger
4,467,805 A 8/1984 Fukuda
4,475,679 A 10/1984 Fleury, Jr.
4,485,816 A 12/1984 Krumme
4,489,875 A 12/1984 Crawford et al.
4,500,024 A 2/1985 DiGiovanni et al.
4,505,273 A 3/1985 Braun et al.
4,505,414 A 3/1985 Filipi
4,506,671 A 3/1985 Green
4,520,817 A 6/1985 Green
4,522,327 A 6/1985 Korthoff et al.
4,526,174 A 7/1985 Froehlich
4,527,724 A 7/1985 Chow et al.
4,530,453 A 7/1985 Green
4,548,202 A 10/1985 Duncan
4,565,189 A 1/1986 Mabuchi
4,566,620 A 1/1986 Green et al.
4,573,469 A 3/1986 Golden et al.
4,573,622 A 3/1986 Green et al.
4,576,167 A 3/1986 Noiles et al.
4,580,712 A 4/1986 Green
4,589,416 A 5/1986 Green
4,591,085 A 5/1986 Di Giovanni
4,604,786 A 8/1986 Howie, Jr.
4,605,001 A 8/1986 Rothfuss et al.
4,606,343 A 8/1986 Conta et al.
4,607,638 A 8/1986 Crainich
4,608,981 A 9/1986 Rothfuss et al.
4,610,250 A 9/1986 Green
4,610,383 A 9/1986 Rothfuss et al.
4,619,262 A 10/1986 Taylor
4,629,107 A 12/1986 Fedotov et al.
4,632,290 A 12/1986 Green et al.
4,633,874 A 1/1987 Chow et al.
4,641,076 A 2/1987 Linden
4,646,722 A 3/1987 Silverstein et al.
4,655,222 A 4/1987 Florez et al.
4,663,874 A 5/1987 Sano et al.
4,664,305 A 5/1987 Blake, III et al.
4,665,916 A 5/1987 Green
4,667,674 A 5/1987 Korthoff et al.
4,671,445 A 6/1987 Barker et al.
4,676,245 A 6/1987 Fukuda
4,693,248 A 9/1987 Failla
4,709,120 A 11/1987 Pearson
4,715,520 A 12/1987 Roehr, Jr. et al.
4,719,917 A 1/1988 Barrows et al.
4,728,020 A 3/1988 Green et al.
4,728,876 A 3/1988 Mongeon et al.
4,729,260 A 3/1988 Dudden
4,741,336 A 5/1988 Failla et al.
4,752,024 A 6/1988 Green et al.
4,754,909 A 7/1988 Barker et al.
4,767,044 A 8/1988 Green
4,777,780 A 10/1988 Holzwarth
4,787,387 A 11/1988 Burbank, III et al.
4,790,225 A 12/1988 Moody et al.
4,805,617 A 2/1989 Bedi et al.
4,805,823 A 2/1989 Rothfuss
4,809,695 A 3/1989 Gwathmey et al.
4,817,847 A 4/1989 Redtenbacher et al.
4,819,853 A 4/1989 Green
4,821,939 A 4/1989 Green
4,827,911 A 5/1989 Broadwin et al.
4,844,068 A 7/1989 Arata et al.
4,869,414 A 9/1989 Green et al.
4,869,415 A 9/1989 Fox
4,880,015 A 11/1989 Nierman
4,890,613 A 1/1990 Golden et al.
4,892,244 A 1/1990 Fox et al.
4,915,100 A 4/1990 Green
4,930,503 A 6/1990 Pruitt
4,932,960 A 6/1990 Green et al.
4,938,408 A 7/1990 Bedi et al.
4,941,623 A 7/1990 Pruitt
4,944,443 A 7/1990 Oddsen et al.
4,955,959 A 9/1990 Tompkins et al.
4,978,049 A 12/1990 Green
4,986,808 A 1/1991 Broadwin et al.
4,988,334 A 1/1991 Hornlein et al.
5,002,553 A 3/1991 Shiber
5,009,661 A 4/1991 Michelson
5,014,899 A 5/1991 Presty et al.
5,015,227 A 5/1991 Broadwin et al.
5,027,834 A 7/1991 Pruitt
5,031,814 A 7/1991 Tompkins et al.
5,040,715 A 8/1991 Green et al.
5,042,707 A 8/1991 Taheri
5,061,269 A 10/1991 Muller
5,062,563 A 11/1991 Green et al.
5,065,929 A 11/1991 Schulze et al.
5,071,052 A 12/1991 Rodak et al.
5,071,430 A 12/1991 de Salis et al.
5,074,454 A 12/1991 Peters
5,080,556 A 1/1992 Carreno
5,083,695 A 1/1992 Foslien et al.
5,084,057 A 1/1992 Green et al.
5,088,979 A 2/1992 Filipi et al.
5,088,997 A 2/1992 Delahuerga et al.
5,094,247 A 3/1992 Hernandez et al.
5,100,420 A 3/1992 Green et al.
5,104,025 A 4/1992 Main et al.
5,106,008 A 4/1992 Tompkins et al.
5,111,987 A 5/1992 Moeinzadeh et al.

5,116,349	A		5/1992	Aranyi
5,129,570	A		7/1992	Schulze et al.
5,137,198	A		8/1992	Nobis et al.
5,139,513	A		8/1992	Segato
5,141,144	A		8/1992	Foslien et al.
5,156,315	A		10/1992	Green et al.
5,156,614	A		10/1992	Green et al.
5,158,567	A		10/1992	Green
D330,699	S		11/1992	Gill
5,163,598	A		11/1992	Peters et al.
5,171,247	A		12/1992	Hughett et al.
5,171,249	A		12/1992	Stefanchik et al.
5,188,111	A		2/1993	Yates et al.
5,190,517	A		3/1993	Zieve et al.
5,195,968	A		3/1993	Lundquist et al.
5,197,648	A		3/1993	Gingold
5,200,280	A		4/1993	Karasa
5,205,459	A		4/1993	Brinkerhoff et al.
5,207,697	A		5/1993	Carusillo et al.
5,209,747	A		5/1993	Knoepfler
5,211,649	A		5/1993	Kohler et al.
5,217,457	A		6/1993	Delahuerga et al.
5,217,478	A		6/1993	Rexroth
5,219,111	A		6/1993	Bilotti et al.
5,221,036	A		6/1993	Takase
5,221,281	A		6/1993	Klicek
5,222,963	A		6/1993	Brinkerhoff et al.
5,222,975	A		6/1993	Crainich
5,222,976	A		6/1993	Yoon
5,223,675	A		6/1993	Taft
5,234,447	A		8/1993	Kaster et al.
5,236,440	A		8/1993	Hlavacek
5,239,981	A		8/1993	Anapliotis
5,240,163	A		8/1993	Stein et al.
5,242,457	A		9/1993	Akopov et al.
5,244,462	A		9/1993	Delahuerga et al.
5,246,156	A		9/1993	Rothfuss et al.
5,246,443	A		9/1993	Mai
5,253,793	A		10/1993	Green et al.
5,258,009	A		11/1993	Conners
5,258,012	A		11/1993	Luscombe et al.
5,259,366	A		11/1993	Reydel et al.
5,260,637	A		11/1993	Pizzi
5,263,629	A		11/1993	Trumbull et al.
5,263,973	A		11/1993	Cook
5,268,622	A		12/1993	Philipp
5,271,543	A		12/1993	Grant et al.
5,271,544	A		12/1993	Fox et al.
RE34,519	E		1/1994	Fox et al.
5,275,323	A		1/1994	Schulze et al.
5,275,608	A		1/1994	Forman et al.
5,281,216	A		1/1994	Klicek
5,282,806	A		2/1994	Haber et al.
5,282,829	A		2/1994	Hermes
5,297,714	A		3/1994	Kramer
5,304,204	A		4/1994	Bregen
5,307,976	A		5/1994	Olson et al.
5,309,927	A		5/1994	Welch
5,312,023	A		5/1994	Green et al.
5,312,329	A		5/1994	Beaty et al.
5,314,424	A		5/1994	Nicholas
5,318,221	A		6/1994	Green et al.
5,330,502	A		7/1994	Hassler et al.
5,332,142	A		7/1994	Robinson et al.
5,333,422	A		8/1994	Warren et al.
5,334,183	A		8/1994	Wuchinich
5,336,232	A		8/1994	Green et al.
5,339,799	A		8/1994	Kami et al.
5,341,724	A		8/1994	Vatel
5,341,810	A		8/1994	Dardel
5,342,395	A		8/1994	Jarrett et al.
5,342,396	A		8/1994	Cook
5,344,060	A		9/1994	Gravener et al.
5,350,400	A		9/1994	Esposito et al.
5,352,235	A		10/1994	Koros et al.
5,352,238	A		10/1994	Green et al.
5,354,303	A		10/1994	Spaeth et al.
5,356,006	A		10/1994	Alpern et al.
5,358,510	A		10/1994	Luscombe et al.
5,359,231	A		10/1994	Flowers et al.
D352,780	S		11/1994	Glaeser et al.
5,360,428	A		11/1994	Hutchinson, Jr.
5,364,003	A		11/1994	Williamson, IV
5,366,134	A		11/1994	Green et al.
5,366,479	A		11/1994	McGarry et al.
5,368,015	A	*	11/1994	Wilk 600/104
5,370,645	A		12/1994	Klicek et al.
5,372,596	A		12/1994	Klicek et al.
5,372,602	A		12/1994	Burke
5,374,277	A		12/1994	Hassler
5,379,933	A		1/1995	Green et al.
5,381,782	A		1/1995	DeLaRama et al.
5,382,247	A		1/1995	Cimino et al.
5,383,880	A		1/1995	Hooven
5,383,881	A		1/1995	Green et al.
5,383,888	A		1/1995	Zvenyatsky et al.
5,383,895	A		1/1995	Holmes et al.
5,389,098	A		2/1995	Tsuruta et al.
5,391,180	A		2/1995	Tovey et al.
5,392,979	A		2/1995	Green et al.
5,395,030	A		3/1995	Kuramoto et al.
5,395,033	A		3/1995	Byrne et al.
5,395,312	A		3/1995	Desai
5,397,046	A		3/1995	Savage et al.
5,397,324	A		3/1995	Carroll et al.
5,403,312	A		4/1995	Yates et al.
5,405,072	A		4/1995	Zlock et al.
5,405,344	A		4/1995	Williamson et al.
5,407,293	A		4/1995	Crainich
5,409,498	A		4/1995	Braddock et al.
5,411,508	A		5/1995	Bessler et al.
5,413,267	A		5/1995	Solyntjes et al.
5,413,268	A		5/1995	Green et al.
5,413,272	A		5/1995	Green et al.
5,415,334	A		5/1995	Williamson, IV et al.
5,415,335	A		5/1995	Knodell, Jr.
5,417,361	A		5/1995	Williamson, IV
5,421,829	A		6/1995	Olichney et al.
5,422,567	A		6/1995	Matsunaga
5,423,809	A		6/1995	Klicek
5,425,745	A		6/1995	Green et al.
5,431,322	A		7/1995	Green et al.
5,431,668	A		7/1995	Burbank, III et al.
5,433,721	A		7/1995	Hooven et al.
5,438,302	A		8/1995	Goble
5,439,479	A		8/1995	Shichman et al.
5,441,193	A		8/1995	Gravener
5,441,494	A		8/1995	Ortiz
5,445,304	A		8/1995	Plyley et al.
5,445,644	A		8/1995	Pietrafitta et al.
5,447,417	A		9/1995	Kuhl et al.
5,447,513	A		9/1995	Davison et al.
5,449,355	A		9/1995	Rhum et al.
5,449,365	A		9/1995	Green et al.
5,452,836	A		9/1995	Huitema et al.
5,452,837	A		9/1995	Williamson, IV et al.
5,454,827	A		10/1995	Aust et al.
5,456,401	A		10/1995	Green et al.
5,458,579	A		10/1995	Chodorow et al.
5,462,215	A		10/1995	Viola et al.
5,464,300	A		11/1995	Crainich
5,465,894	A		11/1995	Clark et al.
5,465,895	A		11/1995	Knodel et al.
5,465,896	A		11/1995	Allen et al.
5,466,020	A		11/1995	Page et al.
5,467,911	A		11/1995	Tsuruta et al.
5,470,006	A		11/1995	Rodak
5,470,007	A		11/1995	Plyley et al.
5,472,132	A		12/1995	Savage et al.
5,472,442	A		12/1995	Klicek
5,473,204	A		12/1995	Temple
5,474,057	A		12/1995	Makower et al.
5,474,566	A		12/1995	Alesi et al.
5,476,206	A		12/1995	Green et al.
5,476,479	A		12/1995	Green et al.
5,478,003	A		12/1995	Green et al.
5,478,354	A		12/1995	Tovey et al.
5,480,089	A		1/1996	Blewett

5,480,409	A	1/1996	Riza	
5,482,197	A	1/1996	Green et al.	
5,484,095	A	1/1996	Green et al.	
5,484,398	A	1/1996	Stoddard	
5,484,451	A	1/1996	Akopov et al.	
5,485,947	A	1/1996	Olson et al.	
5,485,952	A	1/1996	Fontayne	
5,487,499	A	1/1996	Sorrentino et al.	
5,487,500	A	1/1996	Knodel et al.	
5,489,058	A	2/1996	Plyley et al.	
5,489,256	A	2/1996	Adair	
5,496,312	A	3/1996	Klicek	
5,496,317	A	3/1996	Goble et al.	
5,497,933	A	3/1996	DeFonzo et al.	
5,503,320	A	4/1996	Webster et al.	
5,503,635	A	4/1996	Sauer et al.	
5,503,638	A	4/1996	Cooper et al.	
5,505,363	A	4/1996	Green et al.	
5,507,426	A	4/1996	Young et al.	
5,509,596	A	4/1996	Green et al.	
5,509,916	A	4/1996	Taylor	
5,511,564	A	4/1996	Wilk	
5,514,129	A	5/1996	Smith	
5,514,157	A	5/1996	Nicholas et al.	
5,518,163	A	5/1996	Hooven	
5,518,164	A	5/1996	Hooven	
5,520,678	A	5/1996	Heckele et al.	
5,520,700	A	5/1996	Beyar et al.	
5,522,817	A	6/1996	Sander et al.	
5,527,320	A	6/1996	Carruthers et al.	
5,529,235	A	6/1996	Boiarski et al.	
D372,086	S	7/1996	Grasso et al.	
5,531,744	A	7/1996	Nardella et al.	
5,533,521	A	7/1996	Granger	
5,533,581	A	7/1996	Barth et al.	
5,533,661	A	7/1996	Main et al.	
5,535,934	A	7/1996	Boiarski et al.	
5,535,935	A	7/1996	Vidal et al.	
5,535,937	A	7/1996	Boiarski et al.	
5,540,375	A	7/1996	Bolanos et al.	
5,541,376	A	7/1996	Ladtkow et al.	
5,542,594	A	8/1996	McKean et al.	
5,543,119	A	8/1996	Sutter et al.	
5,547,117	A	8/1996	Hamblin et al.	
5,549,621	A	8/1996	Bessler et al.	
5,549,628	A	8/1996	Cooper et al.	
5,549,637	A	8/1996	Crainich	
5,553,675	A	9/1996	Pitzen et al.	
5,553,765	A	9/1996	Knodel et al.	
5,554,169	A	9/1996	Green et al.	
5,556,416	A	9/1996	Clark et al.	
5,558,665	A	9/1996	Kieturakis	
5,558,671	A	9/1996	Yates	
5,560,530	A	10/1996	Bolanos et al.	
5,560,532	A	10/1996	DeFonzo et al.	
5,562,239	A *	10/1996	Boiarski et al.	.... 227/175.2
5,562,241	A	10/1996	Knodel et al.	
5,562,682	A	10/1996	Oberlin et al.	
5,562,701	A	10/1996	Huitema et al.	
5,562,702	A	10/1996	Huitema et al.	
5,564,615	A	10/1996	Bishop et al.	
5,569,161	A	10/1996	Ebling et al.	
5,571,090	A	11/1996	Sherts	
5,571,100	A	11/1996	Goble et al.	
5,571,116	A	11/1996	Bolanos et al.	
5,573,543	A	11/1996	Akopov et al.	
5,574,431	A	11/1996	McKeown et al.	
5,575,789	A	11/1996	Bell et al.	
5,575,799	A	11/1996	Bolanos et al.	
5,575,803	A	11/1996	Cooper et al.	
5,577,654	A	11/1996	Bishop	
5,579,978	A	12/1996	Green et al.	
5,580,067	A	12/1996	Hamblin et al.	
5,582,611	A	12/1996	Tsuruta et al.	
5,582,617	A	12/1996	Klieman et al.	
5,584,425	A	12/1996	Savage et al.	
5,586,711	A	12/1996	Plyley et al.	
5,588,579	A	12/1996	Schnut et al.	
5,588,580	A	12/1996	Paul et al.	
5,588,581	A	12/1996	Conlon et al.	
5,591,170	A	1/1997	Spievack et al.	
5,591,187	A	1/1997	Dekel	
5,597,107	A	1/1997	Knodel et al.	
5,599,151	A	2/1997	Daum et al.	
5,599,344	A	2/1997	Paterson	
5,599,350	A	2/1997	Schulze et al.	
5,601,224	A	2/1997	Bishop et al.	
5,603,443	A	2/1997	Clark et al.	
5,605,272	A	2/1997	Witt et al.	
5,605,273	A	2/1997	Hamblin et al.	
5,607,094	A	3/1997	Clark et al.	
5,607,095	A	3/1997	Smith et al.	
5,607,450	A	3/1997	Zvenyatsky et al.	
5,609,285	A	3/1997	Grant et al.	
5,611,709	A	3/1997	McAnulty	
5,613,966	A	3/1997	Makower et al.	
5,618,294	A	4/1997	Aust et al.	
5,618,303	A	4/1997	Marlow et al.	
5,620,289	A	4/1997	Curry	
5,620,452	A	4/1997	Yoon	
5,624,452	A	4/1997	Yates	
5,626,587	A	5/1997	Bishop et al.	
5,628,446	A	5/1997	Geiste et al.	
5,628,743	A	5/1997	Cimino	
5,630,539	A	5/1997	Plyley et al.	
5,630,540	A	5/1997	Blewett	
5,630,782	A	5/1997	Adair	
5,632,432	A	5/1997	Schulze et al.	
5,632,433	A	5/1997	Grant et al.	
5,634,584	A	6/1997	Okorocha et al.	
5,636,779	A	6/1997	Palmer	
5,636,780	A	6/1997	Green et al.	
5,639,008	A	6/1997	Gallagher et al.	
5,643,291	A	7/1997	Pier et al.	
5,645,209	A	7/1997	Green et al.	
5,647,526	A	7/1997	Green et al.	
5,647,869	A	7/1997	Goble et al.	
5,649,937	A	7/1997	Bito et al.	
5,651,491	A	7/1997	Heaton et al.	
5,653,373	A	8/1997	Green et al.	
5,653,374	A	8/1997	Young et al.	
5,653,677	A	8/1997	Okada et al.	
5,653,721	A	8/1997	Knodel et al.	
5,655,698	A	8/1997	Yoon	
5,657,921	A	8/1997	Young et al.	
5,658,281	A	8/1997	Heard	
5,658,300	A	8/1997	Bito et al.	
5,662,258	A	9/1997	Knodel et al.	
5,662,260	A	9/1997	Yoon	
5,662,662	A	9/1997	Bishop et al.	
5,667,517	A	9/1997	Hooven	
5,667,526	A	9/1997	Levin	
5,667,527	A	9/1997	Cook	
5,669,544	A	9/1997	Schulze et al.	
5,669,904	A	9/1997	Platt, Jr. et al.	
5,669,907	A	9/1997	Platt, Jr. et al.	
5,669,918	A	9/1997	Balazs et al.	
5,673,840	A	10/1997	Schulze et al.	
5,673,841	A	10/1997	Schulze et al.	
5,673,842	A	10/1997	Bittner et al.	
5,678,748	A	10/1997	Plyley et al.	
5,680,981	A	10/1997	Mililli et al.	
5,680,982	A	10/1997	Schulze et al.	
5,680,983	A	10/1997	Plyley et al.	
5,683,349	A	11/1997	Makower et al.	
5,685,474	A	11/1997	Seeber	
5,688,270	A	11/1997	Yates et al.	
5,690,269	A	11/1997	Bolanos et al.	
5,692,668	A	12/1997	Schulze et al.	
5,693,042	A	12/1997	Boiarski et al.	
5,693,051	A	12/1997	Schulze et al.	
5,695,494	A	12/1997	Becker	
5,695,504	A	12/1997	Gifford, III et al.	
5,695,524	A	12/1997	Kelley et al.	
5,697,543	A	12/1997	Burdorff	
5,697,943	A	12/1997	Sauer et al.	
5,700,270	A	12/1997	Peyser et al.	
5,702,387	A	12/1997	Arts et al.	

5,702,408	A	12/1997	Wales et al.
5,702,409	A	12/1997	Rayburn et al.
5,704,087	A	1/1998	Strub
5,704,534	A	1/1998	Huitema et al.
5,706,997	A	1/1998	Green et al.
5,706,998	A	1/1998	Plyley et al.
5,707,392	A	1/1998	Kortenbach
5,709,334	A	1/1998	Sorrentino et al.
5,709,680	A	1/1998	Yates et al.
5,711,472	A	1/1998	Bryan
5,713,128	A	2/1998	Schrenk et al.
5,713,505	A	2/1998	Huitema
5,713,895	A	2/1998	Lontine et al.
5,715,987	A	2/1998	Kelley et al.
5,715,988	A	2/1998	Palmer
5,716,366	A	2/1998	Yates
5,718,359	A	2/1998	Palmer et al.
5,718,360	A	2/1998	Green et al.
5,718,548	A	2/1998	Cotellessa
5,720,744	A	2/1998	Eggleston et al.
D393,067	S	3/1998	Geary et al.
5,725,536	A	3/1998	Oberlin et al.
5,725,554	A	3/1998	Simon et al.
5,728,121	A	3/1998	Bimbo et al.
5,730,758	A	3/1998	Allgeyer
5,732,871	A	3/1998	Clark et al.
5,732,872	A	3/1998	Bolduc et al.
5,735,445	A	4/1998	Vidal et al.
5,735,848	A	4/1998	Yates et al.
5,735,874	A	4/1998	Measamer et al.
5,738,474	A	4/1998	Blewett
5,738,648	A	4/1998	Lands et al.
5,743,456	A	4/1998	Jones et al.
5,747,953	A	5/1998	Philipp
5,749,889	A	5/1998	Bacich et al.
5,749,893	A	5/1998	Vidal et al.
5,752,644	A	5/1998	Bolanos et al.
5,752,965	A	5/1998	Francis et al.
5,755,717	A	5/1998	Yates et al.
5,758,814	A	6/1998	Gallagher et al.
5,762,255	A	6/1998	Chrisman et al.
5,762,256	A	6/1998	Mastri et al.
5,766,188	A	6/1998	Igaki
5,766,205	A	6/1998	Zvenyatsky et al.
5,769,892	A	6/1998	Kingwell
5,772,379	A	6/1998	Evensen
5,772,578	A	6/1998	Heimberger et al.
5,772,659	A	6/1998	Becker et al.
5,776,130	A	7/1998	Buysse et al.
5,779,130	A	7/1998	Alesi et al.
5,779,131	A	7/1998	Knodel et al.
5,779,132	A	7/1998	Knodel et al.
5,782,396	A	7/1998	Mastri et al.
5,782,397	A	7/1998	Koukline
5,782,749	A	7/1998	Riza
5,782,859	A	7/1998	Nicholas et al.
5,784,934	A	7/1998	Izumisawa
5,785,232	A	7/1998	Vidal et al.
5,787,897	A	8/1998	Kieturakis
5,792,135	A	8/1998	Madhani et al.
5,792,165	A	8/1998	Klieman et al.
5,794,834	A	8/1998	Hamblin et al.
5,796,188	A	8/1998	Bays
5,797,536	A	8/1998	Smith et al.
5,797,537	A	8/1998	Oberlin et al.
5,797,538	A	8/1998	Heaton et al.
5,797,906	A	8/1998	Rhum et al.
5,797,959	A	8/1998	Castro et al.
5,799,857	A	9/1998	Robertson et al.
5,807,378	A	9/1998	Jensen et al.
5,807,393	A	9/1998	Williamson, IV et al.
5,809,441	A	9/1998	McKee
5,810,811	A	9/1998	Yates et al.
5,810,855	A	9/1998	Rayburn et al.
5,813,813	A	9/1998	Daum et al.
5,814,057	A	9/1998	Oi et al.
5,817,084	A	10/1998	Jensen
5,817,091	A	10/1998	Nardella et al.
5,817,093	A	10/1998	Williamson, IV et al.
5,817,109	A	10/1998	McGarry et al.
5,817,119	A	10/1998	Klieman et al.
5,820,009	A	10/1998	Melling et al.
5,823,066	A	10/1998	Huitema et al.
5,826,776	A	10/1998	Schulze et al.
5,827,271	A	10/1998	Buysse et al.
5,829,662	A	11/1998	Allen et al.
5,833,690	A	11/1998	Yates et al.
5,833,695	A	11/1998	Yoon
5,833,696	A	11/1998	Whitfield et al.
5,836,503	A	11/1998	Ehrenfels et al.
5,836,960	A	11/1998	Kolesa et al.
5,839,639	A	11/1998	Sauer et al.
5,843,132	A	12/1998	Ilvento
5,846,254	A	12/1998	Schulze et al.
5,849,011	A	12/1998	Jones et al.
5,855,311	A	1/1999	Hamblin et al.
5,855,583	A	1/1999	Wang et al.
5,860,975	A	1/1999	Goble et al.
5,865,361	A	2/1999	Milliman et al.
5,868,760	A	2/1999	McGuckin, Jr.
5,871,135	A	2/1999	Williamson, IV et al.
5,873,885	A	2/1999	Weidenbenner
5,876,401	A	3/1999	Schulze et al.
5,878,193	A	3/1999	Wang et al.
5,878,937	A	3/1999	Green et al.
5,878,938	A	3/1999	Bittner et al.
5,891,160	A	4/1999	Williamson, IV et al.
5,893,506	A	4/1999	Powell
5,894,979	A	4/1999	Powell
5,897,562	A	4/1999	Bolanos et al.
5,899,914	A	5/1999	Zirps et al.
5,901,895	A	5/1999	Heaton et al.
5,902,312	A	5/1999	Frater et al.
5,904,693	A	5/1999	Dicesare et al.
5,906,625	A	5/1999	Bito et al.
5,908,402	A	6/1999	Blythe
5,908,427	A	6/1999	McKean et al.
5,911,353	A	6/1999	Bolanos et al.
5,915,616	A	6/1999	Viola et al.
5,918,791	A	7/1999	Sorrentino et al.
5,919,198	A	7/1999	Graves, Jr. et al.
5,928,256	A	7/1999	Riza
5,931,847	A	8/1999	Bittner et al.
5,931,853	A	8/1999	McEwen et al.
5,937,951	A	8/1999	Izuchukwu et al.
5,938,667	A	8/1999	Peyser et al.
5,941,442	A	8/1999	Geiste et al.
5,944,172	A	8/1999	Hannula
5,944,715	A	8/1999	Goble et al.
5,948,030	A	9/1999	Miller et al.
5,951,552	A	9/1999	Long et al.
5,951,574	A	9/1999	Stefanchik et al.
5,954,259	A	9/1999	Viola et al.
5,964,774	A	10/1999	McKean et al.
5,971,916	A	10/1999	Koren
5,988,479	A	11/1999	Palmer
6,003,517	A	12/1999	Sheffield et al.
6,004,319	A	12/1999	Goble et al.
6,010,054	A	1/2000	Johnson et al.
6,012,494	A	1/2000	Balazs
6,013,076	A	1/2000	Goble et al.
6,015,406	A	1/2000	Goble et al.
6,017,322	A	1/2000	Snoke et al.
6,017,356	A	1/2000	Frederick et al.
6,022,352	A	2/2000	Vandewalle
6,024,741	A	2/2000	Williamson, IV et al.
6,024,748	A	2/2000	Manzo et al.
6,027,501	A	2/2000	Goble et al.
6,032,849	A	3/2000	Mastri et al.
6,033,378	A	3/2000	Lundquist et al.
6,033,399	A	3/2000	Gines
6,033,427	A	3/2000	Lee
6,039,733	A	3/2000	Buysse et al.
6,039,734	A *	3/2000	Goble 606/41
6,045,560	A	4/2000	McKean et al.
6,050,472	A	4/2000	Shibata
6,053,390	A	4/2000	Green et al.
6,056,746	A	5/2000	Goble et al.

6,063,097	A	5/2000	Oi et al.
6,063,098	A	5/2000	Houser et al.
6,068,627	A	5/2000	Orszulak et al.
6,071,233	A	6/2000	Ishikawa et al.
6,074,386	A	6/2000	Goble et al.
6,077,286	A	6/2000	Cuschieri et al.
6,079,606	A	6/2000	Milliman et al.
6,082,577	A	7/2000	Coates et al.
6,083,234	A	7/2000	Nicholas et al.
6,083,242	A	7/2000	Cook
6,086,600	A	7/2000	Kortenbach
6,090,106	A	7/2000	Goble et al.
6,093,186	A	7/2000	Goble
6,099,537	A	8/2000	Sugai et al.
6,099,551	A	8/2000	Gabbay
6,102,271	A	8/2000	Longo et al.
6,109,500	A	8/2000	Alli et al.
6,117,158	A	9/2000	Measamer et al.
6,119,913	A	9/2000	Adams et al.
6,120,433	A	9/2000	Mizuno et al.
6,123,241	A	9/2000	Walter et al.
H1904	H	10/2000	Yates et al.
6,126,058	A	10/2000	Adams et al.
6,126,670	A	10/2000	Walker et al.
6,131,789	A	10/2000	Schulze et al.
6,132,368	A	10/2000	Cooper
6,139,546	A	10/2000	Koenig et al.
6,155,473	A	12/2000	Tompkins et al.
6,156,056	A	12/2000	Kearns et al.
6,159,146	A	12/2000	El Gazayerli
6,159,200	A	12/2000	Verdura et al.
6,162,208	A	12/2000	Hipps
6,165,175	A	12/2000	Wampler et al.
6,165,184	A	12/2000	Verdura et al.
6,168,605	B1	1/2001	Measamer et al.
6,171,316	B1	1/2001	Kovac et al.
6,171,330	B1	1/2001	Benchetrit
6,174,308	B1	1/2001	Goble et al.
6,174,309	B1	1/2001	Wrublewski et al.
6,179,776	B1	1/2001	Adams et al.
6,181,105	B1	1/2001	Cutolo et al.
6,193,129	B1	2/2001	Bittner et al.
6,197,042	B1	3/2001	Ginn et al.
6,202,914	B1	3/2001	Geiste et al.
6,214,028	B1	4/2001	Yoon et al.
6,220,368	B1	4/2001	Ark et al.
6,223,835	B1	5/2001	Habedank et al.
6,228,081	B1	5/2001	Goble
6,228,084	B1	5/2001	Kirwan, Jr.
6,231,565	B1	5/2001	Tovey et al.
6,234,178	B1	5/2001	Goble et al.
6,241,139	B1	6/2001	Milliman et al.
6,241,723	B1	6/2001	Heim et al.
6,249,076	B1	6/2001	Madden et al.
6,250,532	B1	6/2001	Green et al.
6,258,107	B1	7/2001	Balázs et al.
6,261,286	B1	7/2001	Goble et al.
6,264,086	B1	7/2001	McGuckin, Jr.
6,264,087	B1	7/2001	Whitman
6,270,508	B1	8/2001	Klieman et al.
6,273,897	B1	8/2001	Dalessandro et al.
6,277,114	B1	8/2001	Bullivant et al.
6,293,942	B1	9/2001	Goble et al.
6,296,640	B1	10/2001	Wampler et al.
6,302,311	B1	10/2001	Adams et al.
6,306,134	B1	10/2001	Goble et al.
6,309,403	B1	10/2001	Minor et al.
6,315,184	B1	11/2001	Whitman
6,320,123	B1	11/2001	Reimers
6,324,339	B1	11/2001	Hudson et al.
6,325,799	B1	12/2001	Goble
6,325,810	B1	12/2001	Hamilton et al.
6,330,965	B1	12/2001	Milliman et al.
6,331,181	B1	12/2001	Tierney et al.
6,331,761	B1	12/2001	Kumar et al.
6,334,860	B1	1/2002	Dorn
6,336,926	B1	1/2002	Goble
6,346,077	B1	2/2002	Taylor et al.
6,352,503	B1	3/2002	Matsui et al.
6,358,224	B1	3/2002	Tims et al.
6,364,877	B1	4/2002	Goble et al.
6,364,888	B1	4/2002	Niemeyer et al.
6,373,152	B1	4/2002	Wang et al.
6,387,113	B1	5/2002	Hawkins et al.
6,387,114	B2	5/2002	Adams
6,391,038	B2	5/2002	Vargas et al.
6,398,781	B1	6/2002	Goble et al.
6,398,797	B2	6/2002	Bombard et al.
6,406,440	B1	6/2002	Stefanchik
6,409,724	B1	6/2002	Penny et al.
H2037	H	7/2002	Yates et al.
6,416,486	B1	7/2002	Wampler
6,416,509	B1	7/2002	Goble et al.
6,419,695	B1	7/2002	Gabbay
RE37,814	E	8/2002	Allgeyer
6,436,097	B1	8/2002	Nardella
6,436,107	B1	8/2002	Wang et al.
6,436,122	B1	8/2002	Frank et al.
6,439,446	B1	8/2002	Perry et al.
6,440,146	B2	8/2002	Nicholas et al.
6,443,973	B1	9/2002	Whitman
6,450,391	B1	9/2002	Kayan et al.
6,468,275	B1	10/2002	Wampler et al.
6,471,106	B1	10/2002	Reining
6,482,200	B2	11/2002	Shippert
6,485,490	B2	11/2002	Wampler et al.
6,488,196	B1	12/2002	Fenton, Jr.
6,488,197	B1	12/2002	Whitman
6,491,201	B1	12/2002	Whitman
6,491,690	B1	12/2002	Goble et al.
6,491,701	B2	12/2002	Tierney et al.
6,492,785	B1	12/2002	Kasten et al.
6,494,896	B1	12/2002	D'Alessio et al.
6,503,257	B2	1/2003	Grant et al.
6,503,259	B2	1/2003	Huxel et al.
6,505,768	B2	1/2003	Whitman
6,510,854	B2	1/2003	Goble
6,511,468	B1	1/2003	Cragg et al.
6,517,535	B2	2/2003	Edwards
6,517,565	B1	2/2003	Whitman et al.
6,517,566	B1	2/2003	Hovland et al.
6,522,101	B2	2/2003	Malackowski
6,543,456	B1	4/2003	Freeman
6,547,786	B1	4/2003	Goble
6,550,546	B2	4/2003	Thurler et al.
6,551,333	B2	4/2003	Kuhns et al.
6,554,861	B2	4/2003	Knox et al.
6,558,379	B1	5/2003	Batchelor et al.
6,565,560	B1	5/2003	Goble et al.
6,569,085	B2	5/2003	Kortenbach et al.
6,569,171	B2	5/2003	DeGuillebon et al.
6,578,751	B2	6/2003	Hartwick
6,582,427	B1	6/2003	Goble et al.
6,588,643	B2	7/2003	Bolduc et al.
6,589,164	B1	7/2003	Flaherty
6,592,597	B2	7/2003	Grant et al.
6,596,432	B2	7/2003	Kawakami et al.
D478,665	S	8/2003	Isaacs et al.
D478,986	S	8/2003	Johnston et al.
6,601,749	B2	8/2003	Sullivan et al.
6,602,252	B2	8/2003	Mollenauer
6,605,078	B2	8/2003	Adams
6,605,669	B2	8/2003	Awokola et al.
6,616,686	B2	9/2003	Coleman et al.
6,619,529	B2	9/2003	Green et al.
6,620,166	B1	9/2003	Wenstrom, Jr. et al.
6,629,630	B2	10/2003	Adams
6,629,974	B2	10/2003	Penny et al.
6,629,988	B2	10/2003	Weadock
6,636,412	B2	10/2003	Smith
6,638,108	B2	10/2003	Tachi
6,638,285	B2	10/2003	Gabbay
6,641,528	B2	11/2003	Torii
6,644,532	B2	11/2003	Green et al.
6,648,816	B2	11/2003	Irion et al.
D484,243	S	12/2003	Ryan et al.
D484,595	S	12/2003	Ryan et al.
D484,596	S	12/2003	Ryan et al.

6,656,193	B2	12/2003	Grant et al.	
6,666,875	B1	12/2003	Sakurai et al.	
6,669,073	B2	12/2003	Milliman et al.	
6,671,185	B2	12/2003	Duval	
D484,977	S	1/2004	Ryan et al.	
6,676,660	B2	1/2004	Wampler et al.	
6,679,410	B2	1/2004	Würsch et al.	
6,681,978	B2	1/2004	Geiste et al.	
6,681,979	B2	1/2004	Whitman	
6,682,527	B2	1/2004	Strul	
6,682,528	B2	1/2004	Frazier et al.	
6,685,727	B2	2/2004	Fisher et al.	
6,692,507	B2	2/2004	Pugsley et al.	
6,695,199	B2	2/2004	Whitman	
6,698,643	B2	3/2004	Whitman	
6,699,235	B2	3/2004	Wallace et al.	
6,704,210	B1	3/2004	Myers	
6,705,503	B1	3/2004	Pedicini et al.	
6,716,223	B2	4/2004	Leopold et al.	
6,716,232	B1	4/2004	Vidal et al.	
6,716,233	B1	4/2004	Whitman	
6,722,552	B2	4/2004	Fenton, Jr.	
6,723,087	B2	4/2004	O'Neill et al.	
6,723,091	B2	4/2004	Goble et al.	
6,726,697	B2	4/2004	Nicholas et al.	
6,740,030	B2	5/2004	Martone et al.	
6,747,121	B2	6/2004	Gogolewski	
6,749,560	B1	6/2004	Konstorum et al.	
6,752,768	B2	6/2004	Burdorff et al.	
6,752,816	B2	6/2004	Culp et al.	
6,755,195	B1	6/2004	Lemke et al.	
6,755,338	B2	6/2004	Hahnen et al.	
6,758,846	B2	7/2004	Goble et al.	
6,761,685	B2	7/2004	Adams et al.	
6,767,352	B2	7/2004	Field et al.	
6,767,356	B2	7/2004	Kanner et al.	
6,769,594	B2	8/2004	Orban, III	
6,773,438	B1	8/2004	Knodel et al.	
6,780,151	B2	8/2004	Grabover et al.	
6,780,180	B1	8/2004	Goble et al.	
6,783,524	B2	8/2004	Anderson et al.	
6,786,382	B1	9/2004	Hoffman	
6,786,864	B2	9/2004	Matsuura et al.	
6,786,896	B1	9/2004	Madhani et al.	
6,790,173	B2	9/2004	Saadat et al.	
6,793,652	B1	9/2004	Whitman et al.	
6,805,273	B2	10/2004	Bilotti et al.	
6,806,808	B1	10/2004	Watters et al.	
6,808,525	B2	10/2004	Latterell et al.	
6,814,741	B2	11/2004	Bowman et al.	
6,817,508	B1	11/2004	Racenet et al.	
6,817,509	B2	11/2004	Geiste et al.	
6,817,974	B2	11/2004	Cooper et al.	
6,821,273	B2	11/2004	Mollenauer	
6,821,284	B2	11/2004	Sturtz et al.	
6,827,725	B2	12/2004	Batchelor et al.	
6,828,902	B2	12/2004	Casden	
6,830,174	B2	12/2004	Hillstead et al.	
6,832,998	B2	12/2004	Goble	
6,834,001	B2	12/2004	Myono	
6,835,199	B2	12/2004	McGuckin, Jr. et al.	
6,843,403	B2	1/2005	Whitman	
6,843,789	B2	1/2005	Goble	
6,846,307	B2	1/2005	Whitman et al.	
6,846,308	B2	1/2005	Whitman et al.	
6,846,309	B2	1/2005	Whitman et al.	
6,849,071	B2	2/2005	Whitman et al.	
RE38,708	E	3/2005	Bolanos et al.	
6,866,178	B2	3/2005	Adams et al.	
6,866,671	B2	3/2005	Tierney et al.	
6,872,214	B2	3/2005	Sonnenschein et al.	
6,874,669	B2	4/2005	Adams et al.	
6,877,647	B2	4/2005	Green et al.	
6,878,106	B1	4/2005	Herrmann	
6,889,116	B2	5/2005	Jinno	
6,893,435	B2	5/2005	Goble	
6,905,057	B2	6/2005	Swayze et al.	
6,905,497	B2	6/2005	Truckai et al.	
6,913,608	B2	7/2005	Liddicoat et al.	
6,913,613	B2	7/2005	Schwarz et al.	
6,923,803	B2	8/2005	Goble	
6,929,641	B2	8/2005	Goble et al.	
6,931,830	B2	8/2005	Liao	
6,936,042	B2	8/2005	Wallace et al.	
6,939,358	B2	9/2005	Palacios et al.	
6,942,662	B2	9/2005	Goble et al.	
6,945,444	B2	9/2005	Gresham et al.	
6,953,138	B1	10/2005	Dworak et al.	
6,953,139	B2	10/2005	Milliman et al.	
6,959,851	B2	11/2005	Heinrich	
6,959,852	B2	11/2005	Shelton, IV et al.	
6,960,163	B2	11/2005	Ewers et al.	
6,960,220	B2	11/2005	Marino et al.	
6,964,363	B2	11/2005	Wales et al.	
6,966,907	B2	11/2005	Goble	
6,966,909	B2	11/2005	Marshall et al.	
6,972,199	B2 *	12/2005	Lebouitz et al.	438/5
6,974,462	B2	12/2005	Sater	
6,978,921	B2	12/2005	Shelton, IV et al.	
6,978,922	B2	12/2005	Bilotti et al.	
6,981,628	B2	1/2006	Wales	
6,981,941	B2	1/2006	Whitman et al.	
6,981,978	B2	1/2006	Gannoe	
6,984,203	B2	1/2006	Tartaglia et al.	
6,984,231	B2	1/2006	Goble et al.	
6,986,451	B1	1/2006	Mastri et al.	
6,988,649	B2	1/2006	Shelton, IV et al.	
6,988,650	B2	1/2006	Schwemberger et al.	
6,990,796	B2	1/2006	Schnipke et al.	
6,994,708	B2	2/2006	Manzo	
6,997,931	B2	2/2006	Sauer et al.	
7,000,818	B2	2/2006	Shelton, IV et al.	
7,000,819	B2	2/2006	Swayze et al.	
7,001,380	B2	2/2006	Goble	
7,001,408	B2	2/2006	Knodel et al.	
7,008,435	B2	3/2006	Cummins	
7,018,390	B2	3/2006	Turovskiy et al.	
7,025,743	B2	4/2006	Mann et al.	
7,029,435	B2	4/2006	Nakao	
7,032,798	B2	4/2006	Whitman et al.	
7,032,799	B2	4/2006	Viola et al.	
7,033,356	B2	4/2006	Latterell et al.	
7,036,680	B1	5/2006	Flannery	
7,037,344	B2	5/2006	Kagan et al.	
7,044,352	B2	5/2006	Shelton, IV et al.	
7,044,353	B2	5/2006	Mastri et al.	
7,048,687	B1	5/2006	Reuss et al.	
7,052,494	B2	5/2006	Goble et al.	
7,055,730	B2	6/2006	Ehrenfels et al.	
7,055,731	B2	6/2006	Shelton, IV et al.	
7,056,284	B2	6/2006	Martone et al.	
7,056,330	B2	6/2006	Gayton	
7,059,508	B2	6/2006	Shelton, IV et al.	
7,063,712	B2	6/2006	Vargas et al.	
7,066,879	B2	6/2006	Fowler et al.	
7,066,944	B2	6/2006	Laufer et al.	
7,070,083	B2	7/2006	Jankowski	
7,070,559	B2	7/2006	Adams et al.	
7,071,287	B2	7/2006	Rhine et al.	
7,075,770	B1	7/2006	Smith	
7,077,856	B2	7/2006	Whitman	
7,080,769	B2	7/2006	Vresh et al.	
7,081,114	B2	7/2006	Rashidi	
7,083,073	B2	8/2006	Yoshie et al.	
7,083,075	B2	8/2006	Swayze et al.	
7,083,571	B2	8/2006	Wang et al.	
7,083,615	B2	8/2006	Peterson et al.	
7,087,071	B2	8/2006	Nicholas et al.	
7,090,637	B2	8/2006	Danitz et al.	
7,090,673	B2	8/2006	Dycus et al.	
7,090,684	B2	8/2006	McGuckin, Jr. et al.	
7,094,202	B2	8/2006	Nobis et al.	
7,097,089	B2	8/2006	Marczyk	
7,098,794	B2	8/2006	Lindsay et al.	
7,104,741	B2	9/2006	Krohn	
7,108,695	B2	9/2006	Witt et al.	
7,108,701	B2	9/2006	Evens et al.	
7,108,709	B2	9/2006	Cummins	

7,111,769 B2 9/2006 Wales et al.
7,112,214 B2 9/2006 Peterson et al.
RE39,358 E 10/2006 Goble
7,114,642 B2 10/2006 Whitman
7,118,582 B1 10/2006 Wang et al.
7,121,446 B2 10/2006 Arad et al.
7,122,028 B2 10/2006 Looper et al.
7,128,253 B2 10/2006 Mastri et al.
7,128,254 B2 10/2006 Shelton, IV et al.
7,128,748 B2 10/2006 Mooradian et al.
7,131,445 B2 11/2006 Amoah
7,133,601 B2 11/2006 Phillips et al.
7,140,527 B2 11/2006 Ehrenfels et al.
7,140,528 B2 11/2006 Shelton, IV
7,143,923 B2 12/2006 Shelton, IV et al.
7,143,924 B2 12/2006 Scirica et al.
7,143,925 B2 12/2006 Shelton, IV et al.
7,143,926 B2 12/2006 Shelton, IV et al.
7,147,138 B2 12/2006 Shelton, IV
7,147,139 B2 12/2006 Schwemberger et al.
7,147,637 B2 12/2006 Goble
7,147,650 B2 12/2006 Lee
7,150,748 B2 12/2006 Ebbutt et al.
7,153,300 B2 12/2006 Goble
7,156,863 B2 * 1/2007 Sonnenschein et al. 606/219
7,159,750 B2 1/2007 Racenet et al.
7,160,299 B2 1/2007 Baily
7,161,036 B2 1/2007 Oikawa et al.
7,168,604 B2 1/2007 Milliman et al.
7,172,104 B2 2/2007 Scirica et al.
7,179,223 B2 2/2007 Motoki et al.
7,179,267 B2 2/2007 Nolan et al.
7,182,239 B1 2/2007 Myers
7,188,758 B2 3/2007 Viola et al.
7,195,627 B2 3/2007 Amoah et al.
7,204,835 B2 4/2007 Latterell et al.
7,207,233 B2 4/2007 Wadge
7,207,471 B2 4/2007 Heinrich et al.
7,207,472 B2 4/2007 Wukusick et al.
7,208,005 B2 4/2007 Frecker et al.
7,210,609 B2 5/2007 Leiboff et al.
7,211,081 B2 5/2007 Goble
7,211,084 B2 5/2007 Goble et al.
7,213,736 B2 5/2007 Wales et al.
7,214,224 B2 5/2007 Goble
7,217,285 B2 5/2007 Vargas et al.
7,220,260 B2 5/2007 Fleming et al.
7,220,272 B2 5/2007 Weadock
7,225,963 B2 6/2007 Scirica
7,225,964 B2 6/2007 Mastri et al.
7,234,624 B2 6/2007 Gresham et al.
7,235,089 B1 6/2007 McGuckin, Jr.
7,235,302 B2 6/2007 Jing et al.
7,237,708 B1 7/2007 Guy et al.
7,238,195 B2 7/2007 Viola
7,241,288 B2 7/2007 Braun
7,246,734 B2 7/2007 Shelton, IV
7,247,161 B2 7/2007 Johnston et al.
7,252,660 B2 8/2007 Kunz
7,255,696 B2 8/2007 Goble et al.
7,258,262 B2 8/2007 Mastri et al.
7,260,431 B2 8/2007 Libbus et al.
7,265,374 B2 9/2007 Lee et al.
7,267,679 B2 9/2007 McGuckin, Jr. et al.
7,273,483 B2 9/2007 Wiener et al.
7,278,562 B2 10/2007 Mastri et al.
7,278,563 B1 10/2007 Green
7,278,994 B2 10/2007 Goble
7,282,048 B2 10/2007 Goble et al.
7,295,907 B2 11/2007 Lu et al.
7,296,724 B2 11/2007 Green et al.
7,297,149 B2 11/2007 Vitali et al.
7,300,450 B2 11/2007 Vleugels et al.
7,303,106 B2 12/2007 Milliman et al.
7,303,107 B2 12/2007 Milliman et al.
7,303,108 B2 12/2007 Shelton, IV
7,303,556 B2 12/2007 Metzger
7,308,998 B2 12/2007 Mastri et al.
7,324,572 B2 1/2008 Chang
7,328,828 B2 2/2008 Ortiz et al.
7,328,829 B2 2/2008 Arad et al.
7,330,004 B2 2/2008 DeJonge et al.
7,334,717 B2 2/2008 Rethy et al.
7,336,184 B2 2/2008 Smith et al.
7,338,513 B2 3/2008 Lee et al.
7,343,920 B2 3/2008 Toby et al.
7,348,763 B1 3/2008 Reinhart et al.
7,351,258 B2 4/2008 Ricotta et al.
7,354,447 B2 4/2008 Shelton, IV et al.
7,357,287 B2 4/2008 Shelton, IV et al.
7,364,060 B2 4/2008 Milliman
7,364,061 B2 4/2008 Swayze et al.
7,377,928 B2 5/2008 Zubik et al.
7,380,695 B2 6/2008 Doll et al.
7,380,696 B2 6/2008 Shelton, IV et al.
7,388,217 B2 6/2008 Buschbeck et al.
7,396,356 B2 7/2008 Mollenauer
7,398,907 B2 7/2008 Racenet et al.
7,398,908 B2 7/2008 Holsten et al.
7,404,508 B2 7/2008 Smith et al.
7,404,509 B2 7/2008 Ortiz et al.
7,407,075 B2 8/2008 Holsten et al.
7,407,078 B2 8/2008 Shelton, IV et al.
7,410,086 B2 8/2008 Ortiz et al.
7,416,101 B2 8/2008 Shelton, IV et al.
7,418,078 B2 8/2008 Blanz et al.
7,419,080 B2 9/2008 Smith et al.
7,422,136 B1 9/2008 Marczyk
7,422,139 B2 9/2008 Shelton, IV et al.
7,424,965 B2 9/2008 Racenet et al.
7,431,188 B1 10/2008 Marczyk
7,431,189 B2 10/2008 Shelton, IV et al.
7,431,694 B2 10/2008 Stefanchik et al.
7,431,730 B2 10/2008 Viola
7,434,715 B2 10/2008 Shelton, IV et al.
7,434,717 B2 10/2008 Shelton, IV et al.
7,438,209 B1 10/2008 Hess et al.
7,439,354 B2 10/2008 Lenges et al.
7,441,684 B2 10/2008 Shelton, IV et al.
7,441,685 B1 10/2008 Boudreaux
7,442,201 B2 10/2008 Pugsley et al.
7,448,525 B2 11/2008 Shelton, IV et al.
7,455,208 B2 11/2008 Wales et al.
7,461,767 B2 12/2008 Viola et al.
7,464,846 B2 12/2008 Shelton, IV et al.
7,464,847 B2 12/2008 Viola et al.
7,464,849 B2 12/2008 Shelton, IV et al.
7,467,740 B2 12/2008 Shelton, IV et al.
7,467,849 B2 12/2008 Silverbrook et al.
7,472,814 B2 1/2009 Mastri et al.
7,472,815 B2 1/2009 Shelton, IV et al.
7,473,253 B2 1/2009 Dycus et al.
7,479,608 B2 1/2009 Smith
7,481,347 B2 1/2009 Roy
7,481,349 B2 1/2009 Holsten et al.
7,481,824 B2 1/2009 Boudreaux et al.
7,485,133 B2 2/2009 Cannon et al.
7,490,749 B2 2/2009 Schall et al.
7,494,039 B2 2/2009 Racenet et al.
7,494,499 B2 2/2009 Nagase et al.
7,500,979 B2 3/2009 Hueil et al.
7,501,198 B2 3/2009 Barlev et al.
7,506,790 B2 3/2009 Shelton, IV
7,506,791 B2 3/2009 Omaits et al.
7,510,107 B2 3/2009 Timm et al.
7,524,320 B2 4/2009 Tierney et al.
7,530,985 B2 5/2009 Takemoto et al.
7,546,940 B2 6/2009 Milliman et al.
7,547,312 B2 6/2009 Bauman et al.
7,549,563 B2 6/2009 Mather et al.
7,549,564 B2 6/2009 Boudreaux
7,552,854 B2 6/2009 Wixey et al.
7,556,185 B2 7/2009 Viola
7,556,186 B2 7/2009 Milliman
7,559,450 B2 7/2009 Wales et al.
7,559,452 B2 7/2009 Wales et al.
7,563,862 B2 7/2009 Sieg et al.
7,566,300 B2 7/2009 Devierre et al.

7,568,603	B2	8/2009	Shelton, IV et al.
7,568,604	B2	8/2009	Ehrenfels et al.
7,575,144	B2	8/2009	Ortiz et al.
7,588,175	B2	9/2009	Timm et al.
7,588,176	B2	9/2009	Timm et al.
7,597,229	B2	10/2009	Boudreaux et al.
7,600,663	B2	10/2009	Green
7,604,150	B2	10/2009	Boudreaux
7,604,151	B2	10/2009	Hess et al.
7,607,557	B2	10/2009	Shelton, IV et al.
7,611,038	B2	11/2009	Racenet et al.
7,615,003	B2	11/2009	Stefanchik et al.
7,624,902	B2	12/2009	Marczyk et al.
7,631,793	B2	12/2009	Rethy et al.
7,637,409	B2	12/2009	Marczyk
7,641,092	B2	1/2010	Kruszynski et al.
7,641,093	B2	1/2010	Doll et al.
7,644,848	B2	1/2010	Swayze et al.
7,651,498	B2	1/2010	Shifrin et al.
7,656,131	B2	2/2010	Embrey et al.
7,658,312	B2	2/2010	Vidal et al.
7,665,646	B2	2/2010	Prommersberger
7,674,255	B2	3/2010	Braun
7,682,307	B2	3/2010	Danitz et al.
7,686,826	B2	3/2010	Lee et al.
7,691,098	B2	4/2010	Wallace et al.
7,699,204	B2	4/2010	Viola
7,699,859	B2	4/2010	Bombard et al.
7,708,180	B2	5/2010	Murray et al.
7,708,758	B2	5/2010	Lee et al.
7,714,239	B2	5/2010	Smith
7,721,930	B2	5/2010	McKenna et al.
7,722,610	B2	5/2010	Viola et al.
7,726,537	B2	6/2010	Olson et al.
7,726,538	B2	6/2010	Holsten et al.
7,743,960	B2	6/2010	Whitman et al.
7,744,627	B2	6/2010	Orban, III et al.
7,766,821	B2	8/2010	Brunnen et al.
7,766,894	B2	8/2010	Weitzner et al.
7,771,396	B2	8/2010	Stefanchik et al.
7,772,720	B2	8/2010	McGee et al.
7,776,060	B2	8/2010	Mooradian et al.
7,780,054	B2	8/2010	Wales
7,780,055	B2	8/2010	Scirica et al.
7,780,663	B2	8/2010	Yates et al.
7,780,685	B2	8/2010	Hunt et al.
7,784,662	B2	8/2010	Wales et al.
7,803,151	B2	9/2010	Whitman
7,806,891	B2	10/2010	Nowlin et al.
7,815,565	B2	10/2010	Stefanchik et al.
7,824,401	B2	11/2010	Manzo et al.
7,828,794	B2	11/2010	Sartor
7,828,808	B2	11/2010	Hinman et al.
7,832,611	B2	11/2010	Boyden et al.
7,836,400	B2	11/2010	May et al.
7,837,081	B2	11/2010	Holsten et al.
7,845,533	B2	12/2010	Marczyk et al.
7,845,534	B2	12/2010	Viola et al.
7,846,149	B2	12/2010	Jankowski
7,870,989	B2	1/2011	Viola et al.
7,887,530	B2	2/2011	Zemlok et al.
7,905,380	B2	3/2011	Shelton, IV et al.
7,905,381	B2	3/2011	Baxter, III et al.
7,909,191	B2	3/2011	Baker et al.
7,909,221	B2	3/2011	Viola et al.
7,913,891	B2	3/2011	Doll et al.
7,914,543	B2	3/2011	Roth et al.
7,918,377	B2	4/2011	Measamer et al.
7,922,061	B2	4/2011	Shelton, IV et al.
7,922,063	B2	4/2011	Zemlok et al.
7,934,630	B2	5/2011	Shelton, IV et al.
7,938,307	B2	5/2011	Bettuchi
7,942,303	B2	5/2011	Shah
7,942,890	B2	5/2011	D'Agostino et al.
7,950,560	B2	5/2011	Zemlok et al.
7,954,682	B2	6/2011	Giordano et al.
7,954,684	B2	6/2011	Boudreaux
7,954,686	B2	6/2011	Baxter, III et al.
7,959,050	B2	6/2011	Smith et al.
7,963,963	B2	6/2011	Francischelli et al.
7,967,180	B2	6/2011	Scirica
7,972,298	B2	7/2011	Wallace et al.
8,002,795	B2	8/2011	Beetel
8,011,551	B2	9/2011	Marczyk et al.
8,011,555	B2	9/2011	Tarinelli et al.
8,028,883	B2	10/2011	Stopek
8,034,077	B2	10/2011	Smith et al.
8,038,045	B2	10/2011	Bettuchi et al.
8,038,046	B2	10/2011	Smith et al.
8,062,330	B2	11/2011	Prommersberger et al.
D650,074	S	12/2011	Hunt et al.
8,091,756	B2	1/2012	Viola
8,097,017	B2	1/2012	Viola
8,108,072	B2	1/2012	Zhao et al.
8,123,103	B2	2/2012	Milliman
8,152,041	B2	4/2012	Kostrzewski
8,157,152	B2	4/2012	Holsten et al.
8,167,895	B2	5/2012	D'Agostino et al.
8,211,125	B2	7/2012	Spivey
8,220,468	B2	7/2012	Cooper et al.
8,225,799	B2	7/2012	Bettuchi
8,241,271	B2	8/2012	Millman et al.
8,245,898	B2	8/2012	Smith et al.
8,245,901	B2	8/2012	Stopek
8,256,654	B2	9/2012	Bettuchi et al.
8,257,391	B2	9/2012	Orban, III et al.
2002/0022836	A1	2/2002	Goble et al.
2002/0029036	A1	3/2002	Goble et al.
2002/0117534	A1	8/2002	Green et al.
2002/0134811	A1	9/2002	Napier et al.
2002/0165541	A1	11/2002	Whitman
2003/0093103	A1	5/2003	Malackowski et al.
2003/0105478	A1	6/2003	Whitman et al.
2003/0130677	A1	7/2003	Whitman et al.
2003/0139741	A1	7/2003	Goble et al.
2003/0153908	A1	8/2003	Goble et al.
2003/0195387	A1	10/2003	Kortenbach et al.
2003/0205029	A1	11/2003	Chapolini et al.
2003/0216732	A1	11/2003	Truckai et al.
2003/0220660	A1	11/2003	Kortenbach et al.
2004/0002726	A1	1/2004	Nunez et al.
2004/0006335	A1	1/2004	Garrison
2004/0006340	A1	1/2004	Latterell et al.
2004/0006372	A1	1/2004	Racenet et al.
2004/0030333	A1	2/2004	Goble
2004/0034357	A1	2/2004	Beane et al.
2004/0034369	A1	2/2004	Sauer et al.
2004/0044364	A1	3/2004	DeVries et al.
2004/0068161	A1	4/2004	Couvillon, Jr.
2004/0068307	A1	4/2004	Goble
2004/0078037	A1	4/2004	Batchelor et al.
2004/0093024	A1	5/2004	Lousararian et al.
2004/0094597	A1	5/2004	Whitman et al.
2004/0097987	A1	5/2004	Pugsley et al.
2004/0101822	A1	5/2004	Weisner et al.
2004/0108357	A1	6/2004	Milliman et al.
2004/0111081	A1	6/2004	Whitman et al.
2004/0115022	A1	6/2004	Albertson et al.
2004/0116952	A1	6/2004	Sakurai et al.
2004/0147909	A1	7/2004	Johnston et al.
2004/0164123	A1	8/2004	Racenet et al.
2004/0167572	A1	8/2004	Roth et al.
2004/0173659	A1	9/2004	Green et al.
2004/0181219	A1	9/2004	Goble et al.
2004/0186470	A1	9/2004	Goble et al.
2004/0193189	A1	9/2004	Kortenbach et al.
2004/0222268	A1	11/2004	Bilotti et al.
2004/0230214	A1	11/2004	Donofrio et al.
2004/0232201	A1	11/2004	Wenchell et al.
2004/0243151	A1	12/2004	Demmy et al.
2004/0243163	A1	12/2004	Casiano et al.
2004/0243176	A1	12/2004	Hahnen et al.
2004/0254566	A1	12/2004	Plicchi et al.
2004/0254608	A1	12/2004	Huitema et al.
2004/0267310	A1	12/2004	Racenet et al.
2005/0032511	A1	2/2005	Malone et al.
2005/0033357	A1	2/2005	Braun
2005/0054946	A1	3/2005	Krzyzanowski

2005/0059997	A1	3/2005	Bauman et al.	
2005/0070929	A1	3/2005	Dalessandro et al.	
2005/0080454	A1	4/2005	Drews et al.	
2005/0085693	A1	4/2005	Belson et al.	
2005/0090817	A1	4/2005	Phan	
2005/0099290	A1*	5/2005	Govari	340/539.13
2005/0103819	A1	5/2005	Racenet et al.	
2005/0107814	A1	5/2005	Johnston et al.	
2005/0107824	A1	5/2005	Hillstead et al.	
2005/0113820	A1	5/2005	Goble et al.	
2005/0119525	A1	6/2005	Takemoto	
2005/0119669	A1	6/2005	Demmy	
2005/0124855	A1	6/2005	Jaffe et al.	
2005/0125009	A1	6/2005	Perry et al.	
2005/0131173	A1	6/2005	McDaniel et al.	
2005/0131211	A1	6/2005	Bayley et al.	
2005/0131390	A1	6/2005	Heinrich et al.	
2005/0131436	A1	6/2005	Johnston et al.	
2005/0131437	A1	6/2005	Johnston et al.	
2005/0131457	A1	6/2005	Douglas et al.	
2005/0137454	A1	6/2005	Saadat et al.	
2005/0137455	A1	6/2005	Ewers et al.	
2005/0143759	A1	6/2005	Kelly	
2005/0145675	A1	7/2005	Hartwick et al.	
2005/0154258	A1	7/2005	Tartaglia et al.	
2005/0165419	A1	7/2005	Sauer et al.	
2005/0165435	A1	7/2005	Johnston et al.	
2005/0169974	A1	8/2005	Tenerz et al.	
2005/0171522	A1	8/2005	Christopherson	
2005/0177181	A1	8/2005	Kagan et al.	
2005/0182298	A1	8/2005	Ikeda et al.	
2005/0184121	A1	8/2005	Heinrich	
2005/0187545	A1	8/2005	Hooven et al.	
2005/0187572	A1	8/2005	Johnston et al.	
2005/0187576	A1	8/2005	Whitman et al.	
2005/0189397	A1	9/2005	Jankowski	
2005/0192609	A1	9/2005	Whitman et al.	
2005/0192628	A1	9/2005	Viola	
2005/0203550	A1	9/2005	Laufer et al.	
2005/0216055	A1	9/2005	Scirica et al.	
2005/0228224	A1	10/2005	Okada et al.	
2005/0240222	A1	10/2005	Shipp	
2005/0245965	A1	11/2005	Orban, III et al.	
2005/0251128	A1	11/2005	Amoah	
2005/0256522	A1	11/2005	Francischelli et al.	
2005/0261676	A1	11/2005	Hall et al.	
2005/0261677	A1	11/2005	Hall et al.	
2005/0263563	A1	12/2005	Racenet et al.	
2005/0267455	A1	12/2005	Eggers et al.	
2005/0274768	A1	12/2005	Cummins et al.	
2006/0004407	A1	1/2006	Hiles et al.	
2006/0008787	A1	1/2006	Hayman et al.	
2006/0011699	A1	1/2006	Olson et al.	
2006/0015009	A1	1/2006	Jaffe et al.	
2006/0020247	A1	1/2006	Kagan et al.	
2006/0020336	A1	1/2006	Liddicoat	
2006/0025811	A1	2/2006	Shelton, IV	
2006/0025812	A1	2/2006	Shelton, IV	
2006/0025813	A1	2/2006	Shelton et al.	
2006/0047275	A1	3/2006	Goble	
2006/0047303	A1	3/2006	Ortiz et al.	
2006/0047307	A1	3/2006	Ortiz et al.	
2006/0049229	A1	3/2006	Milliman et al.	
2006/0052825	A1	3/2006	Ransick et al.	
2006/0060630	A1	3/2006	Shelton, IV et al.	
2006/0064086	A1	3/2006	Odom	
2006/0079735	A1	4/2006	Martone et al.	
2006/0085031	A1	4/2006	Bettuchi	
2006/0085033	A1	4/2006	Criscuolo et al.	
2006/0086032	A1	4/2006	Valencic et al.	
2006/0100643	A1	5/2006	Laufer et al.	
2006/0108393	A1	5/2006	Heinrich et al.	
2006/0111710	A1	5/2006	Goble et al.	
2006/0111711	A1	5/2006	Goble	
2006/0111723	A1	5/2006	Chapolini et al.	
2006/0122636	A1	6/2006	Bailly et al.	
2006/0129140	A1*	6/2006	Todd et al.	606/1
2006/0142772	A1	6/2006	Ralph et al.	
2006/0149163	A1	7/2006	Hibner et al.	
2006/0161185	A1	7/2006	Saadat et al.	
2006/0173470	A1	8/2006	Oray et al.	
2006/0180634	A1	8/2006	Shelton, IV et al.	
2006/0183246	A1	8/2006	Wiesner et al.	
2006/0200123	A1	9/2006	Ryan	
2006/0212069	A1	9/2006	Shelton, IV	
2006/0217729	A1	9/2006	Eskridge et al.	
2006/0226196	A1	10/2006	Hueil et al.	
2006/0235469	A1	10/2006	Viola	
2006/0241655	A1	10/2006	Viola	
2006/0241692	A1	10/2006	McGuckin, Jr. et al.	
2006/0244460	A1	11/2006	Weaver	
2006/0245971	A1	11/2006	Burns et al.	
2006/0258904	A1	11/2006	Stefanchik et al.	
2006/0259073	A1	11/2006	Miyamoto et al.	
2006/0264927	A1	11/2006	Ryan	
2006/0264929	A1	11/2006	Goble et al.	
2006/0271042	A1	11/2006	Latterell et al.	
2006/0271102	A1	11/2006	Bosshard et al.	
2006/0273135	A1	12/2006	Beetel	
2006/0278680	A1	12/2006	Viola et al.	
2006/0278681	A1	12/2006	Viola et al.	
2006/0289602	A1	12/2006	Wales et al.	
2006/0291981	A1	12/2006	Viola et al.	
2007/0023476	A1	2/2007	Whitman et al.	
2007/0023477	A1	2/2007	Whitman et al.	
2007/0027468	A1	2/2007	Wales et al.	
2007/0027469	A1	2/2007	Smith et al.	
2007/0034668	A1	2/2007	Holsten et al.	
2007/0045379	A1	3/2007	Shelton, IV	
2007/0055219	A1	3/2007	Whitman et al.	
2007/0070574	A1	3/2007	Nerheim et al.	
2007/0073341	A1	3/2007	Smith	
2007/0078484	A1	4/2007	Talarico et al.	
2007/0083193	A1	4/2007	Werneth et al.	
2007/0084897	A1	4/2007	Shelton, IV et al.	
2007/0102453	A1	5/2007	Morgan et al.	
2007/0102472	A1	5/2007	Shelton, IV	
2007/0102473	A1	5/2007	Shelton, IV et al.	
2007/0102474	A1	5/2007	Shelton, IV et al.	
2007/0106113	A1	5/2007	Ravo	
2007/0106317	A1	5/2007	Shelton, IV et al.	
2007/0114261	A1	5/2007	Ortiz et al.	
2007/0118175	A1	5/2007	Butler et al.	
2007/0129605	A1	6/2007	Schaaf	
2007/0135803	A1	6/2007	Belson	
2007/0158358	A1	7/2007	Mason, II et al.	
2007/0158385	A1	7/2007	Hueil et al.	
2007/0170225	A1	7/2007	Shelton, IV et al.	
2007/0173806	A1*	7/2007	Orszulak et al.	606/34
2007/0173813	A1*	7/2007	Odom	606/51
2007/0175949	A1	8/2007	Shelton, IV et al.	
2007/0175950	A1	8/2007	Shelton, IV et al.	
2007/0175951	A1	8/2007	Shelton, IV et al.	
2007/0175953	A1	8/2007	Shelton, IV et al.	
2007/0175955	A1	8/2007	Shelton, IV et al.	
2007/0175957	A1	8/2007	Shelton, IV et al.	
2007/0175958	A1	8/2007	Shelton, IV et al.	
2007/0175964	A1	8/2007	Shelton, IV et al.	
2007/0179476	A1	8/2007	Shelton, IV et al.	
2007/0181632	A1	8/2007	Milliman	
2007/0194079	A1	8/2007	Hueil et al.	
2007/0194080	A1	8/2007	Swayze et al.	
2007/0194081	A1	8/2007	Hueil et al.	
2007/0194082	A1	8/2007	Morgan et al.	
2007/0203510	A1	8/2007	Bettuchi	
2007/0213750	A1	9/2007	Weadock	
2007/0221700	A1	9/2007	Ortiz et al.	
2007/0221701	A1	9/2007	Ortiz et al.	
2007/0225562	A1	9/2007	Spivey et al.	
2007/0233053	A1	10/2007	Shelton, IV et al.	
2007/0239028	A1	10/2007	Houser et al.	
2007/0246505	A1	10/2007	Pace-Floridia et al.	
2007/0260278	A1	11/2007	Wheeler et al.	
2007/0270784	A1	11/2007	Smith et al.	
2007/0270884	A1	11/2007	Smith et al.	
2007/0288044	A1	12/2007	Jinno et al.	
2007/0295780	A1	12/2007	Shelton et al.	
2007/0299427	A1	12/2007	Yeung et al.	

2008/0015598	A1	1/2008	Prommersberger
2008/0029570	A1	2/2008	Shelton et al.
2008/0029573	A1	2/2008	Shelton et al.
2008/0029574	A1	2/2008	Shelton et al.
2008/0029575	A1	2/2008	Shelton et al.
2008/0029576	A1	2/2008	Shelton et al.
2008/0030170	A1	2/2008	Dacquay et al.
2008/0035701	A1	2/2008	Racenet et al.
2008/0041916	A1	2/2008	Milliman et al.
2008/0041917	A1	2/2008	Racenet et al.
2008/0078800	A1	4/2008	Hess et al.
2008/0078801	A1	4/2008	Shelton et al.
2008/0078802	A1	4/2008	Hess et al.
2008/0078803	A1	4/2008	Shelton et al.
2008/0078804	A1	4/2008	Shelton et al.
2008/0078806	A1	4/2008	Omaits et al.
2008/0078807	A1	4/2008	Hess et al.
2008/0078808	A1	4/2008	Hess et al.
2008/0082114	A1	4/2008	McKenna et al.
2008/0082115	A1	4/2008	Morgan et al.
2008/0082124	A1	4/2008	Hess et al.
2008/0082125	A1	4/2008	Murray et al.
2008/0082126	A1	4/2008	Murray et al.
2008/0083813	A1	4/2008	Zemlok et al.
2008/0114385	A1	5/2008	Byrum et al.
2008/0129253	A1	6/2008	Shiue et al.
2008/0140115	A1	6/2008	Stopek
2008/0164296	A1	7/2008	Shelton et al.
2008/0167522	A1	7/2008	Giordano et al.
2008/0167644	A1	7/2008	Shelton et al.
2008/0167670	A1	7/2008	Shelton et al.
2008/0167671	A1	7/2008	Giordano et al.
2008/0167672	A1	7/2008	Giordano et al.
2008/0167736	A1	7/2008	Swayze et al.
2008/0169328	A1	7/2008	Shelton
2008/0169329	A1	7/2008	Shelton et al.
2008/0169330	A1	7/2008	Shelton et al.
2008/0169331	A1	7/2008	Shelton et al.
2008/0169332	A1	7/2008	Shelton et al.
2008/0169333	A1	7/2008	Shelton et al.
2008/0172087	A1	7/2008	Fuchs et al.
2008/0172088	A1	7/2008	Smith et al.
2008/0185419	A1	8/2008	Smith et al.
2008/0197167	A1	8/2008	Viola et al.
2008/0200835	A1	8/2008	Monson et al.
2008/0210738	A1	9/2008	Shelton et al.
2008/0228029	A1	9/2008	Mikkaichi et al.
2008/0237296	A1	10/2008	Boudreaux et al.
2008/0245841	A1	10/2008	Smith et al.
2008/0251568	A1	10/2008	Zemlok et al.
2008/0251569	A1	10/2008	Smith et al.
2008/0255413	A1	10/2008	Zemlok et al.
2008/0262654	A1	10/2008	Omori et al.
2008/0283570	A1	11/2008	Boyden et al.
2008/0287944	A1	11/2008	Pearson et al.
2008/0290134	A1	11/2008	Bettuchi et al.
2008/0296343	A1	12/2008	Schall et al.
2008/0296345	A1	12/2008	Shelton, IV et al.
2008/0296346	A1	12/2008	Shelton, IV et al.
2008/0296347	A1	12/2008	Shelton, IV et al.
2008/0300579	A1	12/2008	Broehl et al.
2008/0300580	A1	12/2008	Shelton, IV et al.
2008/0300613	A1	12/2008	Shelton, IV et al.
2008/0308601	A1	12/2008	Timm et al.
2008/0308602	A1	12/2008	Timm et al.
2008/0308603	A1	12/2008	Shelton, IV et al.
2008/0308608	A1	12/2008	Prommersberger
2008/0314954	A1	12/2008	Boudreaux
2008/0314955	A1	12/2008	Boudreaux et al.
2008/0314957	A1	12/2008	Boudreaux
2008/0314960	A1	12/2008	Marczyk et al.
2009/0001121	A1	1/2009	Hess et al.
2009/0001122	A1	1/2009	Prommersberger et al.
2009/0001123	A1	1/2009	Morgan et al.
2009/0001124	A1	1/2009	Hess et al.
2009/0001125	A1	1/2009	Hess et al.
2009/0001128	A1	1/2009	Weisenburgh, II et al.
2009/0001130	A1	1/2009	Hess et al.
2009/0005807	A1	1/2009	Hess et al.
2009/0005808	A1	1/2009	Hess et al.
2009/0005809	A1	1/2009	Hess et al.
2009/0012534	A1	1/2009	Madhani et al.
2009/0012556	A1	1/2009	Boudreaux et al.
2009/0020958	A1	1/2009	Soul
2009/0054908	A1 *	2/2009	Zand et al. 606/130
2009/0057369	A1	3/2009	Smith et al.
2009/0076534	A1	3/2009	Shelton, IV et al.
2009/0090763	A1	4/2009	Zemlok et al.
2009/0093728	A1	4/2009	Hyde et al.
2009/0108048	A1	4/2009	Zemlok et al.
2009/0114701	A1	5/2009	Zemlok et al.
2009/0143805	A1	6/2009	Palmer et al.
2009/0149871	A9	6/2009	Kagan et al.
2009/0157067	A1 *	6/2009	Kane et al. 606/33
2009/0200355	A1	8/2009	Baxter, III et al.
2009/0206123	A1	8/2009	Doll et al.
2009/0206124	A1	8/2009	Hall et al.
2009/0206125	A1	8/2009	Huitema et al.
2009/0206126	A1	8/2009	Huitema et al.
2009/0206128	A1	8/2009	Hueil et al.
2009/0206129	A1	8/2009	Doll et al.
2009/0206130	A1	8/2009	Hall et al.
2009/0206131	A1	8/2009	Weisenburgh, II et al.
2009/0206132	A1	8/2009	Hueil et al.
2009/0206133	A1	8/2009	Morgan et al.
2009/0206134	A1	8/2009	Swayze et al.
2009/0206135	A1	8/2009	Hall et al.
2009/0206136	A1	8/2009	Moore et al.
2009/0206137	A1	8/2009	Hall et al.
2009/0206138	A1	8/2009	Smith et al.
2009/0206139	A1	8/2009	Hall et al.
2009/0206140	A1	8/2009	Scheib et al.
2009/0206141	A1	8/2009	Huitema et al.
2009/0206142	A1	8/2009	Huitema et al.
2009/0206143	A1	8/2009	Huitema et al.
2009/0206144	A1	8/2009	Doll et al.
2009/0209946	A1	8/2009	Swayze et al.
2009/0209979	A1	8/2009	Yates et al.
2009/0209990	A1	8/2009	Yates et al.
2009/0213685	A1	8/2009	Mak et al.
2009/0218384	A1	9/2009	Aranyi
2009/0242610	A1	10/2009	Shelton, IV et al.
2009/0255974	A1	10/2009	Viola
2009/0255975	A1	10/2009	Zemlok et al.
2009/0255976	A1	10/2009	Marczyk et al.
2009/0255977	A1	10/2009	Zemlok
2009/0255978	A1	10/2009	Viola et al.
2009/0289096	A1	11/2009	Shelton, IV et al.
2009/0292283	A1 *	11/2009	Odom 606/51
2009/0308907	A1	12/2009	Nalagatla et al.
2010/0001036	A1	1/2010	Marczyk et al.
2010/0012704	A1	1/2010	Tarinelli Racenet et al.
2010/0023024	A1	1/2010	Zeiner et al.
2010/0032470	A1	2/2010	Hess et al.
2010/0049084	A1	2/2010	Nock et al.
2010/0065605	A1	3/2010	Shelton, IV et al.
2010/0065609	A1	3/2010	Schwemberger
2010/0069942	A1	3/2010	Shelton, IV
2010/0072251	A1	3/2010	Baxter, III et al.
2010/0072252	A1	3/2010	Baxter, III et al.
2010/0072253	A1	3/2010	Baxter, III et al.
2010/0072254	A1	3/2010	Aranyi et al.
2010/0072256	A1	3/2010	Baxter, III et al.
2010/0076474	A1	3/2010	Yates et al.
2010/0076475	A1	3/2010	Yates et al.
2010/0089970	A1	4/2010	Smith et al.
2010/0089972	A1	4/2010	Marczyk
2010/0089974	A1	4/2010	Shelton, IV
2010/0096431	A1	4/2010	Smith et al.
2010/0096435	A1	4/2010	Fuchs et al.
2010/0108740	A1	5/2010	Pastorelli et al.
2010/0108741	A1	5/2010	Hessler et al.
2010/0127042	A1	5/2010	Shelton, IV
2010/0133317	A1	6/2010	Shelton, IV et al.
2010/0133318	A1	6/2010	Boudreaux
2010/0145146	A1	6/2010	Melder
2010/0163598	A1	7/2010	Belzer
2010/0179382	A1	7/2010	Shelton, IV et al.

2010/0181364	A1	7/2010	Shelton, IV et al.
2010/0186219	A1	7/2010	Smith
2010/0193566	A1	8/2010	Schieb et al.
2010/0193567	A1	8/2010	Scheib et al.
2010/0193568	A1	8/2010	Scheib et al.
2010/0193569	A1	8/2010	Yates et al.
2010/0198220	A1	8/2010	Boudreaux et al.
2010/0200637	A1	8/2010	Beetel
2010/0213241	A1	8/2010	Bedi et al.
2010/0222901	A1	9/2010	Swayze et al.
2010/0224669	A1	9/2010	Shelton, IV et al.
2010/0230465	A1	9/2010	Smith et al.
2010/0237132	A1	9/2010	Measamer et al.
2010/0243707	A1	9/2010	Olson et al.
2010/0243708	A1	9/2010	Aranyi et al.
2010/0243709	A1	9/2010	Hess et al.
2010/0258611	A1	10/2010	Smith et al.
2010/0264193	A1	10/2010	Huang et al.
2010/0264194	A1	10/2010	Huang et al.
2010/0276471	A1	11/2010	Whitman
2010/0294827	A1	11/2010	Boyden et al.
2010/0294829	A1	11/2010	Giordano et al.
2010/0301095	A1	12/2010	Shelton, IV et al.
2010/0301096	A1	12/2010	Moore et al.
2010/0305552	A1	12/2010	Shelton, IV et al.
2010/0308100	A1	12/2010	Boudreaux
2010/0312261	A1	12/2010	Suzuki et al.
2011/0006099	A1	1/2011	Hall et al.
2011/0006101	A1	1/2011	Hall et al.
2011/0006103	A1	1/2011	Laurent et al.
2011/0011914	A1	1/2011	Baxter, III et al.
2011/0011915	A1	1/2011	Shelton, IV
2011/0017801	A1	1/2011	Zemlok et al.
2011/0022032	A1	1/2011	Zemlok et al.
2011/0024477	A1	2/2011	Hall et al.
2011/0024478	A1	2/2011	Shelton, IV
2011/0024479	A1	2/2011	Swensgard et al.
2011/0036887	A1	2/2011	Zemlok et al.
2011/0042441	A1	2/2011	Shelton, IV et al.
2011/0060363	A1	3/2011	Hess et al.
2011/0062212	A1	3/2011	Shelton, IV et al.
2011/0068145	A1	3/2011	Bedi et al.
2011/0068148	A1	3/2011	Hall et al.
2011/0084112	A1	4/2011	Kostrzewski
2011/0084113	A1	4/2011	Bedi et al.
2011/0084115	A1	4/2011	Bedi et al.
2011/0087276	A1	4/2011	Bedi et al.
2011/0087279	A1	4/2011	Shah et al.
2011/0095068	A1	4/2011	Patel
2011/0101065	A1	5/2011	Milliman
2011/0114697	A1	5/2011	Baxter, III et al.
2011/0114698	A1	5/2011	Baxter, III et al.
2011/0114699	A1	5/2011	Baxter, III et al.
2011/0114700	A1	5/2011	Baxter, III et al.
2011/0118761	A1	5/2011	Baxter, III et al.
2011/0121051	A1	5/2011	Shelton, IV et al.
2011/0121052	A1	5/2011	Shelton, IV et al.
2011/0125176	A1	5/2011	Yates et al.
2011/0125177	A1	5/2011	Yates et al.
2011/0132962	A1	6/2011	Hall et al.
2011/0132963	A1	6/2011	Giordano et al.
2011/0132964	A1	6/2011	Weisenburgh, II et al.
2011/0132965	A1	6/2011	Moore et al.
2011/0139852	A1	6/2011	Zingman
2011/0144430	A1	6/2011	Spivey et al.
2011/0147433	A1	6/2011	Shelton, IV et al.
2011/0147434	A1	6/2011	Hueil et al.
2011/0155780	A1	6/2011	Boudreaux
2011/0155781	A1	6/2011	Swensgard et al.
2011/0155785	A1	6/2011	Laurent et al.
2011/0155787	A1	6/2011	Baxter, III et al.
2011/0163147	A1	7/2011	Laurent et al.
2011/0174860	A1	7/2011	Shelton, IV et al.
2011/0174861	A1	7/2011	Shelton, IV et al.
2011/0174863	A1	7/2011	Shelton, IV et al.
2011/0178536	A1	7/2011	Kostrzewski
2011/0192882	A1	8/2011	Hess et al.
2011/0210156	A1	9/2011	Smith et al.
2011/0226837	A1	9/2011	Baxter, III et al.
2011/0233258	A1	9/2011	Boudreaux
2011/0253766	A1	10/2011	Baxter, III et al.
2011/0275901	A1	11/2011	Shelton, IV
2011/0276083	A1	11/2011	Shelton, IV et al.
2011/0288573	A1	11/2011	Yates et al.
2011/0290851	A1	12/2011	Shelton, IV
2011/0290853	A1	12/2011	Shelton, IV et al.
2011/0290854	A1	12/2011	Timm et al.
2011/0290855	A1	12/2011	Moore et al.
2011/0290856	A1	12/2011	Shelton, IV et al.
2011/0290857	A1	12/2011	Shelton, IV et al.
2011/0295242	A1	12/2011	Spivey et al.
2011/0295269	A1	12/2011	Swensgard et al.
2011/0295270	A1	12/2011	Giordano et al.
2011/0295295	A1	12/2011	Shelton, IV et al.
2012/0022523	A1	1/2012	Smith et al.
2012/0024934	A1	2/2012	Shelton, IV et al.
2012/0024935	A1	2/2012	Shelton, IV et al.
2012/0024936	A1	2/2012	Baxter, III et al.
2012/0029272	A1	2/2012	Shelton, IV et al.
2012/0029544	A1	2/2012	Shelton, IV et al.
2012/0029547	A1	2/2012	Shelton, IV et al.
2012/0046692	A1	2/2012	Smith et al.
2012/0061448	A1	3/2012	Zingman
2012/0071711	A1	3/2012	Shelton, IV et al.
2012/0071866	A1	3/2012	Kerr et al.
2012/0074196	A1	3/2012	Shelton, IV et al.
2012/0074198	A1	3/2012	Huitema et al.
2012/0074200	A1	3/2012	Schmid et al.
2012/0074201	A1	3/2012	Baxter, III et al.
2012/0080332	A1	4/2012	Shelton, IV et al.
2012/0080333	A1	4/2012	Woodard, Jr. et al.
2012/0080334	A1	4/2012	Shelton, IV et al.
2012/0080335	A1	4/2012	Shelton, IV et al.
2012/0080336	A1	4/2012	Shelton, IV et al.
2012/0080337	A1	4/2012	Shelton, IV et al.
2012/0080338	A1	4/2012	Shelton, IV et al.
2012/0080339	A1	4/2012	Shelton, IV et al.
2012/0080340	A1	4/2012	Shelton, IV et al.
2012/0080344	A1	4/2012	Shelton, IV
2012/0080345	A1	4/2012	Morgan et al.
2012/0080475	A1	4/2012	Smith et al.
2012/0080477	A1	4/2012	Leimbach et al.
2012/0080478	A1	4/2012	Morgan et al.
2012/0080479	A1	4/2012	Shelton, IV
2012/0080480	A1	4/2012	Woodard, Jr. et al.
2012/0080481	A1	4/2012	Widenhouse et al.
2012/0080482	A1	4/2012	Schall et al.
2012/0080483	A1	4/2012	Riestenberg et al.
2012/0080484	A1	4/2012	Morgan et al.
2012/0080485	A1	4/2012	Woodard, Jr. et al.
2012/0080486	A1	4/2012	Woodard, Jr. et al.
2012/0080487	A1	4/2012	Woodard, Jr. et al.
2012/0080488	A1	4/2012	Shelton, IV et al.
2012/0080489	A1	4/2012	Shelton, IV et al.
2012/0080490	A1	4/2012	Shelton, IV et al.
2012/0080491	A1	4/2012	Shelton, IV et al.
2012/0080493	A1	4/2012	Shelton, IV et al.
2012/0080496	A1	4/2012	Schall et al.
2012/0080498	A1	4/2012	Shelton, IV et al.
2012/0080499	A1	4/2012	Schall et al.
2012/0080500	A1	4/2012	Morgan et al.
2012/0080501	A1	4/2012	Morgan et al.
2012/0080502	A1	4/2012	Morgan et al.
2012/0080503	A1	4/2012	Woodard, Jr. et al.
2012/0083833	A1	4/2012	Shelton, IV et al.
2012/0083834	A1	4/2012	Shelton, IV et al.
2012/0083835	A1	4/2012	Shelton, IV et al.
2012/0083836	A1	4/2012	Shelton, IV et al.
2012/0132450	A1	5/2012	Timm et al.
2012/0138660	A1	6/2012	Shelton, IV
2012/0160721	A1	6/2012	Shelton, IV et al.
2012/0175399	A1	7/2012	Shelton et al.
2012/0187179	A1	7/2012	Gleiman
2012/0199630	A1	8/2012	Shelton, IV et al.
2012/0199631	A1	8/2012	Shelton, IV et al.
2012/0199632	A1	8/2012	Spivey et al.
2012/0199633	A1	8/2012	Shelton, IV et al.
2012/0203247	A1	8/2012	Shelton, IV et al.

2012/0205421	A1	8/2012	Shelton, IV
2012/0211546	A1	8/2012	Shelton, IV
2012/0234890	A1	9/2012	Aronhalt et al.
2012/0234891	A1	9/2012	Aronhalt et al.
2012/0234892	A1	9/2012	Aronhalt et al.
2012/0234893	A1	9/2012	Schuckmann et al.
2012/0234895	A1	9/2012	O'Connor et al.
2012/0234896	A1	9/2012	Ellerhorst et al.
2012/0234897	A1	9/2012	Shelton, IV et al.
2012/0234898	A1	9/2012	Shelton, IV et al.
2012/0234899	A1	9/2012	Scheib et al.
2012/0234900	A1	9/2012	Swayze
2012/0238823	A1	9/2012	Hagerty et al.
2012/0238824	A1	9/2012	Widenhouse et al.
2012/0238826	A1	9/2012	Yoo et al.
2012/0238829	A1	9/2012	Shelton, IV et al.
2012/0239009	A1	9/2012	Mollere et al.
2012/0239010	A1	9/2012	Shelton, IV et al.
2012/0239012	A1	9/2012	Laurent et al.
2012/0239075	A1	9/2012	Widenhouse et al.
2012/0239082	A1	9/2012	Shelton, IV et al.
2012/0241491	A1	9/2012	Aldridge et al.
2012/0241492	A1	9/2012	Shelton, IV et al.
2012/0241493	A1	9/2012	Baxter, III et al.
2012/0241496	A1	9/2012	Vasudevan et al.
2012/0241497	A1	9/2012	Vasudevan et al.
2012/0241498	A1	9/2012	Gonzalez et al.
2012/0241499	A1	9/2012	Baxter, III et al.
2012/0241500	A1	9/2012	Timmer et al.
2012/0241501	A1	9/2012	Swayze et al.
2012/0241502	A1	9/2012	Aldridge et al.
2012/0241503	A1	9/2012	Baxter, III et al.
2012/0241505	A1	9/2012	Alexander, III et al.
2012/0248169	A1	10/2012	Widenhouse et al.
2012/0253298	A1	10/2012	Henderson et al.
2012/0265230	A1	10/2012	Yates et al.
2012/0273551	A1	11/2012	Shelton, IV et al.
2012/0283707	A1	11/2012	Giordano et al.
2012/0286019	A1	11/2012	Hueil et al.
2012/0292367	A1	11/2012	Morgan et al.
2012/0292370	A1	11/2012	Hess et al.
2012/0298719	A1	11/2012	Shelton, IV et al.
2013/0012931	A1	1/2013	Spivey et al.
2013/0012957	A1	1/2013	Shelton, IV et al.

FOREIGN PATENT DOCUMENTS

CA	2514274	A1	1/2006
CN	1634601	A	7/2005
CN	1868411	A	11/2006
CN	1915180	A	2/2007
CN	101095621	A	1/2008
DE	273689	C	5/1914
DE	1775926	A	1/1972
DE	3036217	A1	4/1982
DE	3210466	A1	9/1983
DE	9412228	U	9/1994
DE	19509116	A1	9/1996
DE	19851291	A1	1/2000
DE	19924311	A1	11/2000
DE	69328576	T2	1/2001
DE	10052679	A1	5/2001
DE	20112837	U1	10/2001
DE	20121753	U1	4/2003
DE	10314072	A1	10/2004
DE	202007003114	U1	6/2007
EP	0122046	A1	10/1984
EP	0070230	B1	10/1985
EP	0156774	A2	10/1985
EP	0387980	B1	10/1985
EP	0033548	B1	5/1986
EP	0129442	B1	11/1987
EP	0276104	A2	7/1988
EP	0178941	B1	1/1991
EP	0248844	B1	1/1993
EP	0545029	A1	6/1993
EP	0277959	B1	10/1993
EP	0233940	B1	11/1993
EP	0261230	B1	11/1993
EP	0639349	A2	2/1994
EP	0324636	B1	3/1994
EP	0593920	A1	4/1994
EP	0594148	A1	4/1994
EP	0427949	B1	6/1994
EP	0523174	B1	6/1994
EP	0600182	A2	6/1994
EP	0310431	B1	11/1994
EP	0375302	B1	11/1994
EP	0376562	B1	11/1994
EP	0630612	A1	12/1994
EP	0634144	A1	1/1995
EP	0646356	A2	4/1995
EP	0646357	A1	4/1995
EP	0653189	A2	5/1995
EP	0669104	A1	8/1995
EP	0511470	B1	10/1995
EP	0679367	A2	11/1995
EP	0392547	B1	12/1995
EP	0685204	A1	12/1995
EP	0364216	B1	1/1996
EP	0699418	A1	3/1996
EP	0702937	A1	3/1996
EP	0705571	A1	4/1996
EP	0711611	A2	5/1996
EP	0484677	B2	6/1996
EP	0541987	B1	7/1996
EP	0667119	B1	7/1996
EP	0708618	B1	3/1997
EP	0770355	A1	5/1997
EP	0503662	B1	6/1997
EP	0447121	B1	7/1997
EP	0625077	B1	7/1997
EP	0633749	B1	8/1997
EP	0710090	B1	8/1997
EP	0578425	B1	9/1997
EP	0625335	B1	11/1997
EP	0552423	B1	1/1998
EP	0592244	B1	1/1998
EP	0648476	B1	1/1998
EP	0649290	B1	3/1998
EP	0598618	B1	9/1998
EP	0676173	B1	9/1998
EP	0678007	B1	9/1998
EP	0603472	B1	11/1998
EP	0605351	B1	11/1998
EP	0878169	A1	11/1998
EP	0879742	A1	11/1998
EP	0695144	B1	12/1998
EP	0722296	B1	12/1998
EP	0760230	B1	2/1999
EP	0623316	B1	3/1999
EP	0650701	B1	3/1999
EP	0537572	B1	6/1999
EP	0923907	A1	6/1999
EP	0843906	B1	3/2000
EP	0552050	B1	5/2000
EP	0833592	B1	5/2000
EP	0830094	B1	9/2000
EP	1034747	A1	9/2000
EP	1034748	A1	9/2000
EP	0694290	B1	11/2000
EP	1050278	A1	11/2000
EP	1053719	A1	11/2000
EP	1053720	A1	11/2000
EP	1055399	A1	11/2000
EP	1055400	A1	11/2000
EP	1080694	A1	3/2001
EP	1090592	A1	4/2001
EP	1095627	A1	5/2001
EP	1256318	B1	5/2001
EP	0806914	B1	9/2001
EP	0768840	B1	12/2001
EP	0908152	B1	1/2002
EP	0872213	B1	5/2002
EP	0862386	B1	6/2002
EP	0949886	B1	9/2002
EP	1238634	A2	9/2002
EP	0858295	B1	12/2002
EP	0656188	B1	1/2003

EP	1284120 A1	2/2003
EP	1287788 A1	3/2003
EP	0717966 B1	4/2003
EP	0869742 B1	5/2003
EP	0829235 B1	6/2003
EP	0887046 B1	7/2003
EP	0852480 B1	8/2003
EP	0891154 B1	9/2003
EP	0813843 B1	10/2003
EP	0873089 B1	10/2003
EP	0856326 B1	11/2003
EP	1374788 A1	1/2004
EP	0741996 B1	2/2004
EP	0814712 B1	2/2004
EP	1402837 A1	3/2004
EP	0705570 B1	4/2004
EP	0959784 B1	4/2004
EP	1407719 A2	4/2004
EP	1086713 B1	5/2004
EP	0996378 B1	6/2004
EP	1426012 A1	6/2004
EP	0833593 B2	7/2004
EP	1442694 A1	8/2004
EP	0888749 B1	9/2004
EP	0959786 B1	9/2004
EP	1459695 A1	9/2004
EP	1473819 A1	11/2004
EP	1477119 A1	11/2004
EP	1479345 A1	11/2004
EP	1479347 A1	11/2004
EP	1479348 A1	11/2004
EP	0754437 B2	12/2004
EP	1025807 B1	12/2004
EP	1001710 B1	1/2005
EP	1520521 A1	4/2005
EP	1520523 A1	4/2005
EP	1520525 A1	4/2005
EP	1522264 A1	4/2005
EP	1523942 A2	4/2005
EP	1550408 A1	7/2005
EP	1557129 A1	7/2005
EP	1064883 B1	8/2005
EP	1067876 B1	8/2005
EP	0870473 B1	9/2005
EP	1157666 B1	9/2005
EP	0880338 B1	10/2005
EP	1158917 B1	11/2005
EP	1344498 B1	11/2005
EP	1330989 B1	12/2005
EP	0771176 B2	1/2006
EP	1621138 A2	2/2006
EP	1621139 A2	2/2006
EP	1621141 A2	2/2006
EP	1621145 A2	2/2006
EP	1621151 A2	2/2006
EP	1034746 B1	3/2006
EP	1632191 A2	3/2006
EP	1065981 B1	5/2006
EP	1082944 B1	5/2006
EP	1652481 A2	5/2006
EP	1382303 B1	6/2006
EP	1253866 B1	7/2006
EP	1032318 B1	8/2006
EP	1045672 B1	8/2006
EP	1617768 B1	8/2006
EP	1693015 A2	8/2006
EP	1400214 B1	9/2006
EP	1702567 A2	9/2006
EP	1129665 B1	11/2006
EP	1400206 B1	11/2006
EP	1721568 A1	11/2006
EP	1256317 B1	12/2006
EP	1285633 B1	12/2006
EP	1728473 A1	12/2006
EP	1728475 A2	12/2006
EP	1479346 B1	1/2007
EP	1484024 B1	1/2007
EP	1754445 A2	2/2007
EP	1759812 A1	3/2007
EP	1767163 A1	3/2007
EP	1769756 A1	4/2007
EP	1769758 A1	4/2007
EP	1581128 B1	5/2007
EP	1785097 A2	5/2007
EP	1790293 A2	5/2007
EP	1800610 A1	6/2007
EP	1300117 B1	8/2007
EP	1813199 A1	8/2007
EP	1813201 A1	8/2007
EP	1813203 A2	8/2007
EP	1813207 A1	8/2007
EP	1813209 A1	8/2007
EP	1487359 B1	10/2007
EP	1599146 B1	10/2007
EP	1839596 A1	10/2007
EP	2110083 A2	10/2007
EP	1857057 A2	11/2007
EP	1402821 B1	12/2007
EP	1872727 A1	1/2008
EP	1897502 A1	3/2008
EP	1330201 B1	6/2008
EP	1702568 B1	7/2008
EP	1943957 A2	7/2008
EP	1943964 A1	7/2008
EP	1943976 A2	7/2008
EP	1593337 B1	8/2008
EP	1970014 A1	9/2008
EP	1980213 A2	10/2008
EP	1759645 B1	11/2008
EP	1990014 A2	11/2008
EP	1693008 B1	12/2008
EP	1759640 B1	12/2008
EP	2000102 A2	12/2008
EP	2008595 A2	12/2008
EP	1736104 B1	3/2009
EP	1749486 B1	3/2009
EP	2039316 A2	3/2009
EP	1721576 B1	4/2009
EP	1733686 B1	4/2009
EP	2044890 A1	4/2009
EP	1550413 B1	6/2009
EP	1745748 B1	8/2009
EP	2090237 A1	8/2009
EP	2090244 A2	8/2009
EP	2090245 A1	8/2009
EP	2090256 A2	8/2009
EP	2095777 A2	9/2009
EP	2110082 A1	10/2009
EP	1813208 B1	11/2009
EP	2116195 A1	11/2009
EP	1607050 B1	12/2009
EP	1815804 B1	12/2009
EP	1566150 B1	4/2010
EP	1813206 B1	4/2010
EP	1769754 B1	6/2010
EP	1535565 B1	10/2010
EP	1702570 B1	10/2010
EP	1785098 B1	10/2010
EP	2030578 B1	11/2010
EP	1627605 B1	12/2010
EP	1813205 B1	6/2011
EP	1785102 B1	1/2012
FR	999646 A	2/1952
FR	1112936 A	3/1956
FR	2598905 A1	11/1987
FR	2765794 A	1/1999
GB	939929 A	10/1963
GB	1210522 A	10/1970
GB	1217159 A	12/1970
GB	1339394 A	12/1973
GB	2109241 A	6/1983
GB	2272159 A	5/1994
GB	2284242 A	5/1995
GB	2336214 A	10/1999
GB	2425903 A	11/2006
JP	S 58500053 A	1/1983
JP	61-98249 A	5/1986
JP	63-203149	8/1988

JP	3-12126	A	1/1991
JP	5-212039	A	8/1993
JP	6007357	A	1/1994
JP	7051273	A	2/1995
JP	8033641	A	2/1996
JP	8229050	A	9/1996
JP	2000033071	A	2/2000
JP	2000171730	A	6/2000
JP	2000287987	A	10/2000
JP	2000325303	A	11/2000
JP	2001-514541	A	9/2001
JP	2001286477	A	10/2001
JP	2002143078	A	5/2002
JP	2002369820	A	12/2002
JP	2003-500153	A	1/2003
JP	2004-344663		12/2004
JP	2005-028149	A	2/2005
JP	2005505322	T	2/2005
JP	2005103293	A	4/2005
JP	2005131163	A	5/2005
JP	2005131164	A	5/2005
JP	2005131173	A	5/2005
JP	2005131211	A	5/2005
JP	2005131212	A	5/2005
JP	2005137423	A	6/2005
JP	2005152416	A	6/2005
JP	2005-523105	A	8/2005
JP	2005524474	A	8/2005
JP	2006-281405	A	10/2006
RU	2008830	C1	3/1994
RU	2187249	C2	8/2002
RU	2225170	C2	3/2004
SU	189517	A	1/1967
SU	328636	A	9/1972
SU	886900	A1	12/1981
SU	1009439	A	4/1983
SU	1333319	A2	8/1987
SU	1377053	A1	2/1988
SU	1561964	A1	5/1990
SU	1722476	A1	3/1992
WO	WO 82/02824	A1	9/1982
WO	WO 91/15157	A1	10/1991
WO	WO 92/20295	A1	11/1992
WO	WO 92/21300	A1	12/1992
WO	WO 93/08755	A1	5/1993
WO	WO 93/13718	A1	7/1993
WO	WO 93/14690	A1	8/1993
WO	WO 93/15850	A1	8/1993
WO	WO 9315648	A1 *	8/1993
WO	WO 93/19681	A1	10/1993
WO	WO 94/00060	A1	1/1994
WO	WO 94/11057	A1	5/1994
WO	WO 94/12108	A1	6/1994
WO	WO 94/18893	A1	9/1994
WO	WO 94/22378	A1	10/1994
WO	WO 94/23659	A1	10/1994
WO	WO 95/02369	A1	1/1995
WO	WO 95/03743	A1	2/1995
WO	WO 95/06817	A1	3/1995
WO	WO 95/09576	A1	4/1995
WO	WO 95/09577	A1	4/1995
WO	WO 95/14436	A1	6/1995
WO	WO 95/17855	A1	7/1995
WO	WO 95/18383	A1	7/1995
WO	WO 95/18572	A1	7/1995
WO	WO 95/19739	A1	7/1995
WO	WO 95/20360	A1	8/1995
WO	WO 95/23557	A1	9/1995
WO	WO 95/24865	A1	9/1995
WO	WO 95/25471	A3	9/1995
WO	WO 95/26562	A1	10/1995
WO	WO 95/29639	A1	11/1995
WO	WO 96/04858	A1	2/1996
WO	WO 96/19151	A1	6/1996
WO	WO 96/19152	A1	6/1996
WO	WO 96/20652	A1	7/1996
WO	WO 96/21119	A1	7/1996
WO	WO 96/22055	A1	7/1996
WO	WO 96/23448	A1	8/1996
WO	WO 96/24301	A1	8/1996
WO	WO 96/27337	A1	9/1996
WO	WO 96/31155	A1	10/1996
WO	WO 96/35464	A1	11/1996
WO	WO 96/39085	A1	12/1996
WO	WO 96/39086	A1	12/1996
WO	WO 96/39087	A1	12/1996
WO	WO 96/39088	A1	12/1996
WO	WO 96/39089	A1	12/1996
WO	WO 97/00646	A1	1/1997
WO	WO 97/00647	A1	1/1997
WO	WO 97/06582	A1	2/1997
WO	WO 97/10763	A1	3/1997
WO	WO 97/10764	A1	3/1997
WO	WO 97/11648	A2	4/1997
WO	WO 97/11649	A1	4/1997
WO	WO 97/15237	A1	5/1997
WO	WO 97/24073	A1	7/1997
WO	WO 97/24993	A1	7/1997
WO	WO 97/30644	A1	8/1997
WO	WO 97/34533	A1	9/1997
WO	WO 97/37598	A1	10/1997
WO	WO 97/39688	A2	10/1997
WO	WO 98/17180	A1	4/1998
WO	WO 98/27880	A1	7/1998
WO	WO 98/30153	A1	7/1998
WO	WO 98/47436	A1	10/1998
WO	WO 99/03407	A1	1/1999
WO	WO 99/03408	A1	1/1999
WO	WO 99/03409	A1	1/1999
WO	WO 99/12483	A1	3/1999
WO	WO 99/12487	A1	3/1999
WO	WO 99/12488	A1	3/1999
WO	WO 99/15086	A1	4/1999
WO	WO 99/15091	A1	4/1999
WO	WO 99/23933	A2	5/1999
WO	WO 99/23959	A1	5/1999
WO	WO 99/25261	A1	5/1999
WO	WO 99/29244	A1	6/1999
WO	WO 99/34744	A1	7/1999
WO	WO 99/45849	A1	9/1999
WO	WO 99/48430	A1	9/1999
WO	WO 99/51158	A1	10/1999
WO	WO 00/24322	A1	5/2000
WO	WO 00/24330	A1	5/2000
WO	WO 00/41638	A1	7/2000
WO	WO 00/48506	A1	8/2000
WO	WO 00/53112	A2	9/2000
WO	WO 00/54653	A1	9/2000
WO	WO 00/57796	A1	10/2000
WO	WO 00/64365	A1	11/2000
WO	WO 00/72762	A1	12/2000
WO	WO 00/72765	A1	12/2000
WO	WO 01/03587	A1	1/2001
WO	WO 01/05702	A1	1/2001
WO	WO 01/10482	A1	2/2001
WO	WO 01/35845	A1	5/2001
WO	WO 01/54594	A1	8/2001
WO	WO 01/58371	A1	8/2001
WO	WO 01/62158	A2	8/2001
WO	WO 01/62161	A1	8/2001
WO	WO 01/62162	A1	8/2001
WO	WO 01/62164	A2	8/2001
WO	WO 01/62169	A2	8/2001
WO	WO 01/78605	A2	10/2001
WO	WO 01/91646	A1	12/2001
WO	WO 02/07608	A2	1/2002
WO	WO 02/07618	A1	1/2002
WO	WO 02/17799	A1	3/2002
WO	WO 02/19920	A1	3/2002
WO	WO 02/19932	A1	3/2002
WO	WO 02/30297	A2	4/2002
WO	WO 02/32322	A2	4/2002
WO	WO 02/36028	A1	5/2002
WO	WO 02/43571	A2	6/2002
WO	WO 02/058568	A1	8/2002
WO	WO 02/060328	A1	8/2002
WO	WO 02/067785	A2	9/2002
WO	WO 02/098302	A1	12/2002

WO	WO 03/000138	A2	1/2003
WO	WO 03/001329	A2	1/2003
WO	WO 03/013363	A1	2/2003
WO	WO 03/015604	A2	2/2003
WO	WO 03/020106	A2	3/2003
WO	WO 03/020139	A2	3/2003
WO	WO 03/024339	A1	3/2003
WO	WO 03/079909	A3	3/2003
WO	WO 03/030743	A2	4/2003
WO	WO 03/037193	A1	5/2003
WO	WO 03/047436	A3	6/2003
WO	WO 03/055402	A1	7/2003
WO	WO 03/057048	A1	7/2003
WO	WO 03/057058	A1	7/2003
WO	WO 03/063694	A1	8/2003
WO	WO 03/077769	A1	9/2003
WO	WO 03/079911	A1	10/2003
WO	WO 03/082126	A1	10/2003
WO	WO 03/088845	A2	10/2003
WO	WO 03/090630	A2	11/2003
WO	WO 03/094743	A1	11/2003
WO	WO 03/094745	A1	11/2003
WO	WO 03/094746	A1	11/2003
WO	WO 03/094747	A1	11/2003
WO	WO 03090630	A2 *	11/2003
WO	WO 03/101313	A1	12/2003
WO	WO 03/105698	A2	12/2003
WO	WO 03/105702	A2	12/2003
WO	WO 2004/006980	A2	1/2004
WO	WO 2004/011037	A2	2/2004
WO	WO 2004/019769	A1	3/2004
WO	WO 2004/021868	A2	3/2004
WO	WO 2004/028585	A2	4/2004
WO	WO 2004/032754	A2	4/2004
WO	WO 2004/032760	A2	4/2004
WO	WO 2004/032762	A1	4/2004
WO	WO 2004/032763	A2	4/2004
WO	WO 2004/034875	A2	4/2004
WO	WO 2004/047626	A1	6/2004
WO	WO 2004/047653	A2	6/2004
WO	WO 2004/049956	A2	6/2004
WO	WO 2004/052426	A2	6/2004
WO	WO 2004/056276	A1	7/2004
WO	WO 2004/056277	A1	7/2004
WO	WO 2004/062516	A1	7/2004
WO	WO 2004/078050	A2	9/2004
WO	WO 2004/078051	A2	9/2004
WO	WO 2004/086987	A1	10/2004
WO	WO 2004/096015	A2	11/2004
WO	WO 2004/096057	A2	11/2004
WO	WO 2004/103157	A2	12/2004
WO	WO 2004/105593	A1	12/2004
WO	WO 2004/105621	A1	12/2004
WO	WO 2004/112618	A2	12/2004
WO	WO 2004/112652	A2	12/2004
WO	WO 2005/027983	A2	3/2005
WO	WO 2005/037329	A2	4/2005
WO	WO 2005/044078	A2	5/2005
WO	WO 2005/055846	A1	6/2005
WO	WO 2005/072634	A2	8/2005
WO	WO 2005/078892	A1	8/2005
WO	WO 2005/079675	A2	9/2005
WO	WO 2005/096954	A2	10/2005
WO	WO 2005/112806	A2	12/2005
WO	WO 2005/112808	A1	12/2005
WO	WO 2005/115251	A2	12/2005
WO	WO 2005/115253	A2	12/2005
WO	WO 2005/117735	A1	12/2005
WO	WO 2005/122936	A1	12/2005
WO	WO 2006/027014	A1	3/2006
WO	WO 2006/044490	A2	4/2006
WO	WO 2006/044581	A2	4/2006
WO	WO 2006/044810	A2	4/2006
WO	WO 2006/051252	A1	5/2006
WO	WO 2006/059067	A1	6/2006
WO	WO 2006/083748	A1	8/2006
WO	WO 2006/092563	A1	9/2006
WO	WO 2006/092565	A1	9/2006
WO	WO 2006/115958	A1	11/2006
WO	WO 2006/125940	A1	11/2006
WO	WO 2006/132992	A1	12/2006
WO	WO 2007/002180	A2	1/2007
WO	WO 2007/016290	A2	2/2007
WO	WO 2007/018898	A2	2/2007
WO	WO 2007/098220	A2	8/2007
WO	WO 2007/121579	A1	11/2007
WO	WO 2007/131110	A2	11/2007
WO	WO 2007/137304	A2	11/2007
WO	WO 2007/139734	A2	12/2007
WO	WO 2007/142625	A2	12/2007
WO	WO 2007/147439	A1	12/2007
WO	WO 2008/021969	A2	2/2008
WO	WO 2008/039249	A1	4/2008
WO	WO 2008/039270	A1	4/2008
WO	WO 2008/045383	A2	4/2008
WO	WO 2008/070763	A1	6/2008
WO	WO 2008/089404	A2	7/2008
WO	WO 2008/109125	A1	9/2008
WO	WO 2010/063795	A1	6/2010
WO	WO 2012/044844	A2	4/2012

OTHER PUBLICATIONS

Disclosed Anonymously, “Motor-Driven Surgical Stapler Improvements,” Research Disclosure Database No. 526041, Published: Feb. 2008.

C.C. Thompson et al., “Peroral Endoscopic Reduction of Dilated Gastrojejunal Anastomosis After Roux-en-Y Gastric Bypass: A Possible New Option for Patients with Weight Regain,” Surg Endosc (2006) vol. 20, pp. 1744-1748.

B.R. Coolman, DVM, MS et al., “Comparison of Skin Staples With Sutures for Anastomosis of the Small Intestine in Dogs,” Abstract; http://www.blackwell-synergy.com/doi/abs/10.1053/jvet.2000.7539?cookieSet=1&journalCode=vsu which redirects to http://www3.interscience.wiley.com/journal/119040681/abstract?CRETRY=1&SRETRY=0; [online] accessed: Sep. 22, 2008 (2 pages).

The Sodem Aseptic Battery Transfer Kit, Sodem Systems, 2000, 3 pages.

“Biomedical Coatings,” Fort Wayne Metals, Research Products Corporation, obtained online at www.fwmetals.com on Jun. 21, 2010 (1 page).

Van Meer et al., “A Disposable Plastic Compact Wrist for Smart Minimally Invasive Surgical Tools,” LAAS/CNRS (Aug. 2005).

Breedveld et al., “A New, Easily Miniaturized Sterrable Endoscope,” IEEE Engineering in Medicine and Biology Magazine (Nov./Dec. 2005).

D. Tuite, Ed., “Get the Lowdown on Ultracapacitors,” Nov. 15, 2007; [online] URL: http://electronicdesign.com/Articles/Print.cfm?ArticleID=17465, accessed Jan. 15, 2008 (5 pages).

Datasheet for Panasonic TK Relays Ultra Low Profile 2 a Polarized Relay, Copyright Matsushita Electric Works, Ltd. (Known of at least as early as Aug. 17, 2010), 5 pages.

ASTM procedure D2240-00, “Standard Test Method for Rubber Property-Durometer Hardness,” (Published Aug. 2000).

ASTM procedure D2240-05, “Standard Test Method for Rubber Property-Durometer Hardness,” (Published Apr. 2010).

U.S. Appl. No. 13/488,903, filed Jun. 5, 2012.

European Examination Report, Application No. 08250080.2, dated Jun. 14, 2010 (4 pages).

International Search Report for PCT/US2012/026997, May 7, 2012 (5 pages).

Written Opinion for PCT/US2012/026997, May 7, 2012 (6 pages).

International Search Report for PCT/US2012/039156, Oct. 29, 2012 (4 pages).

Written Opinion for PCT/US2012/039156, Oct. 29, 2012 (6 pages).

European Search Report for Application No. 12173458.6, dated Dec. 6, 2012 (8 pages).

* cited by examiner

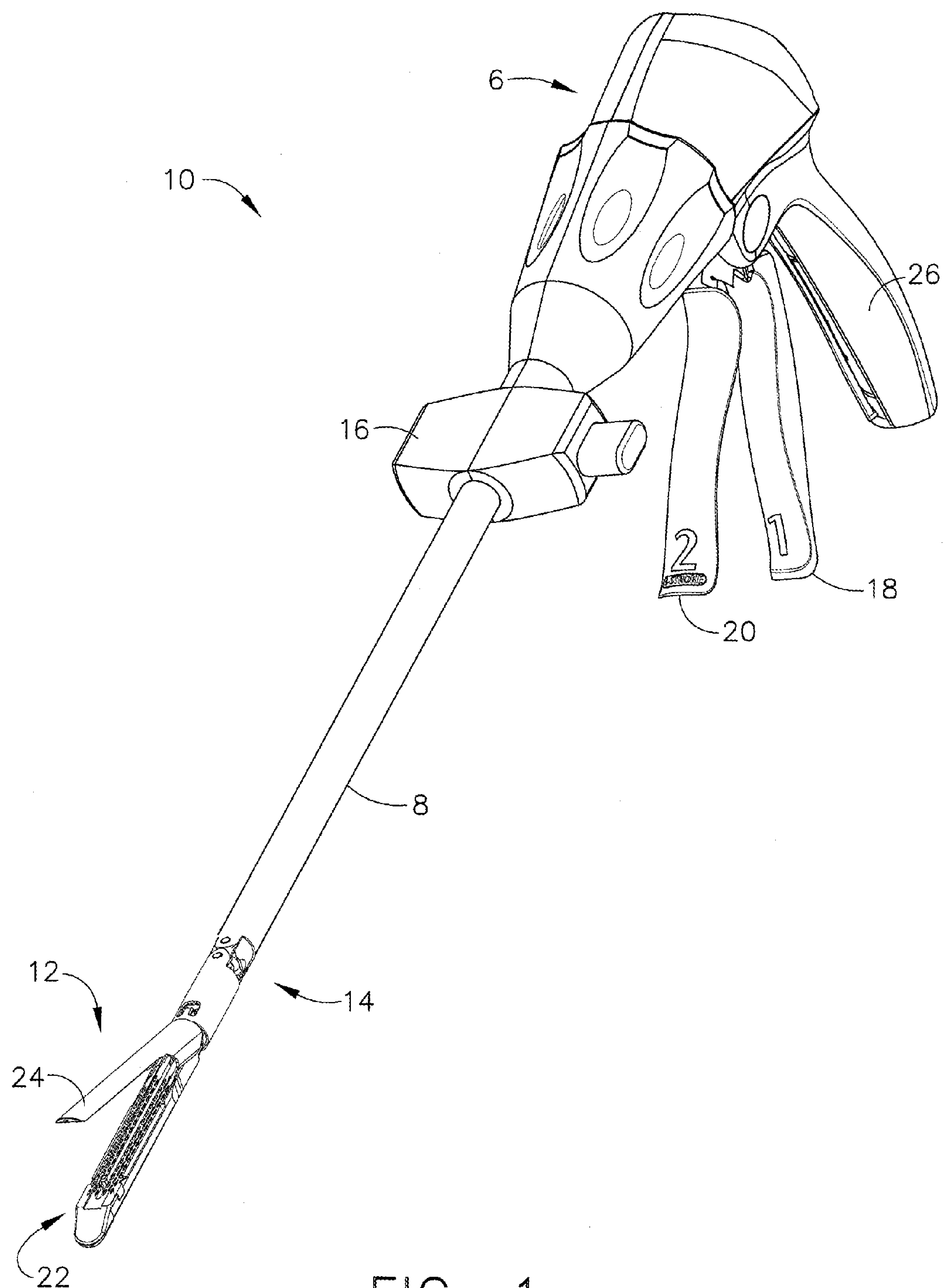


FIG. 1

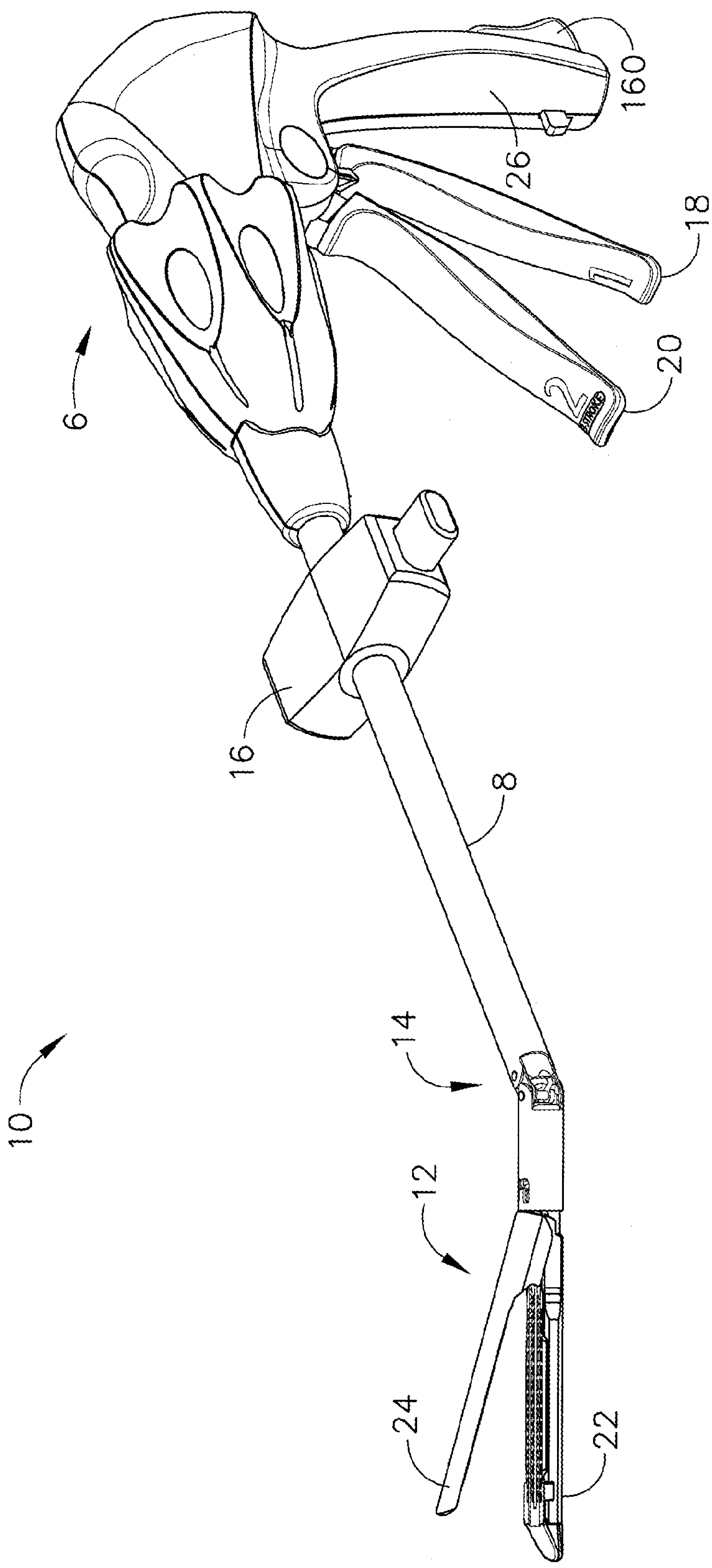


FIG. 2

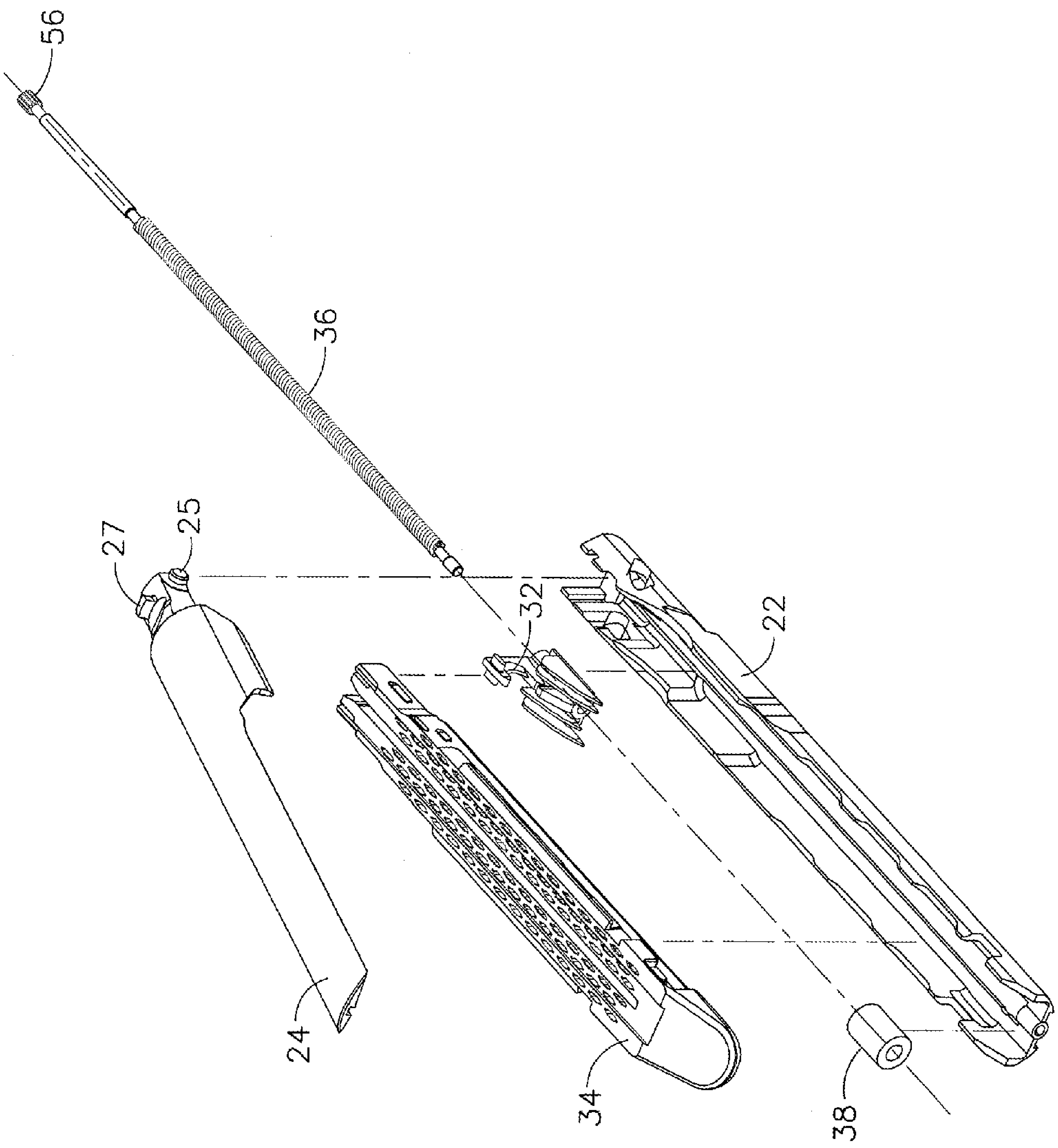


FIG. 3

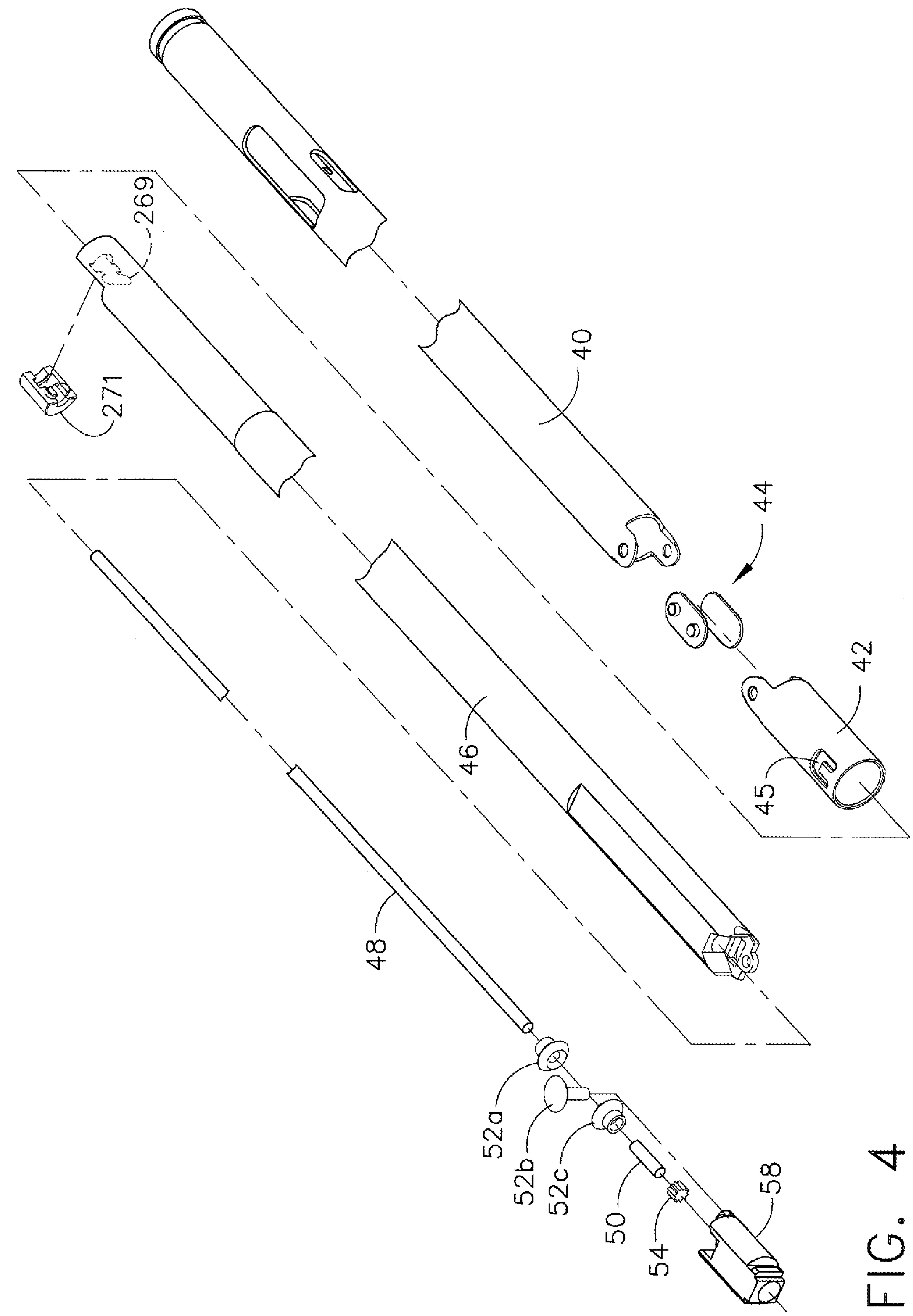


FIG. 4

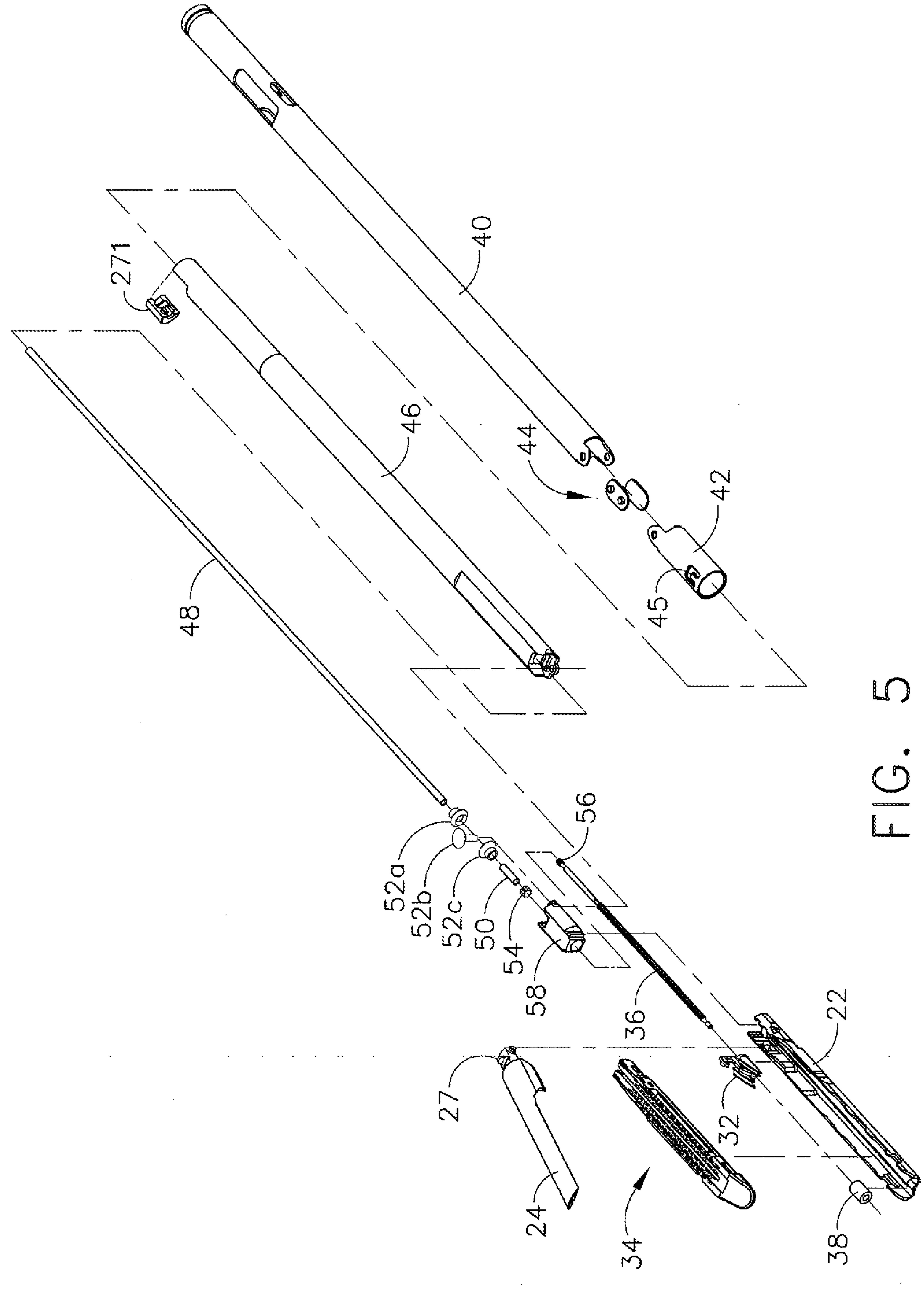


FIG. 5

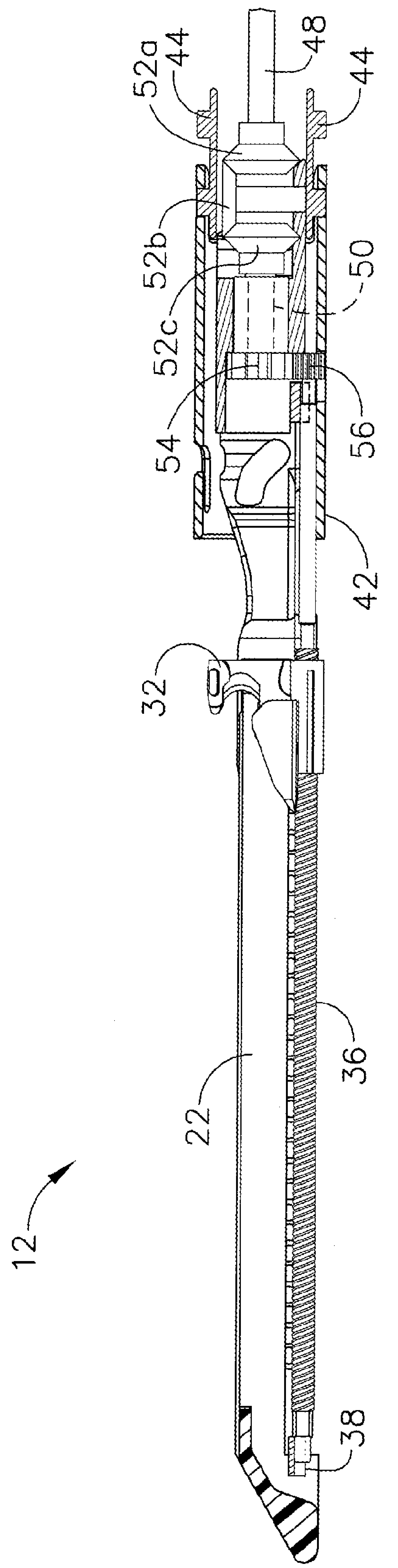
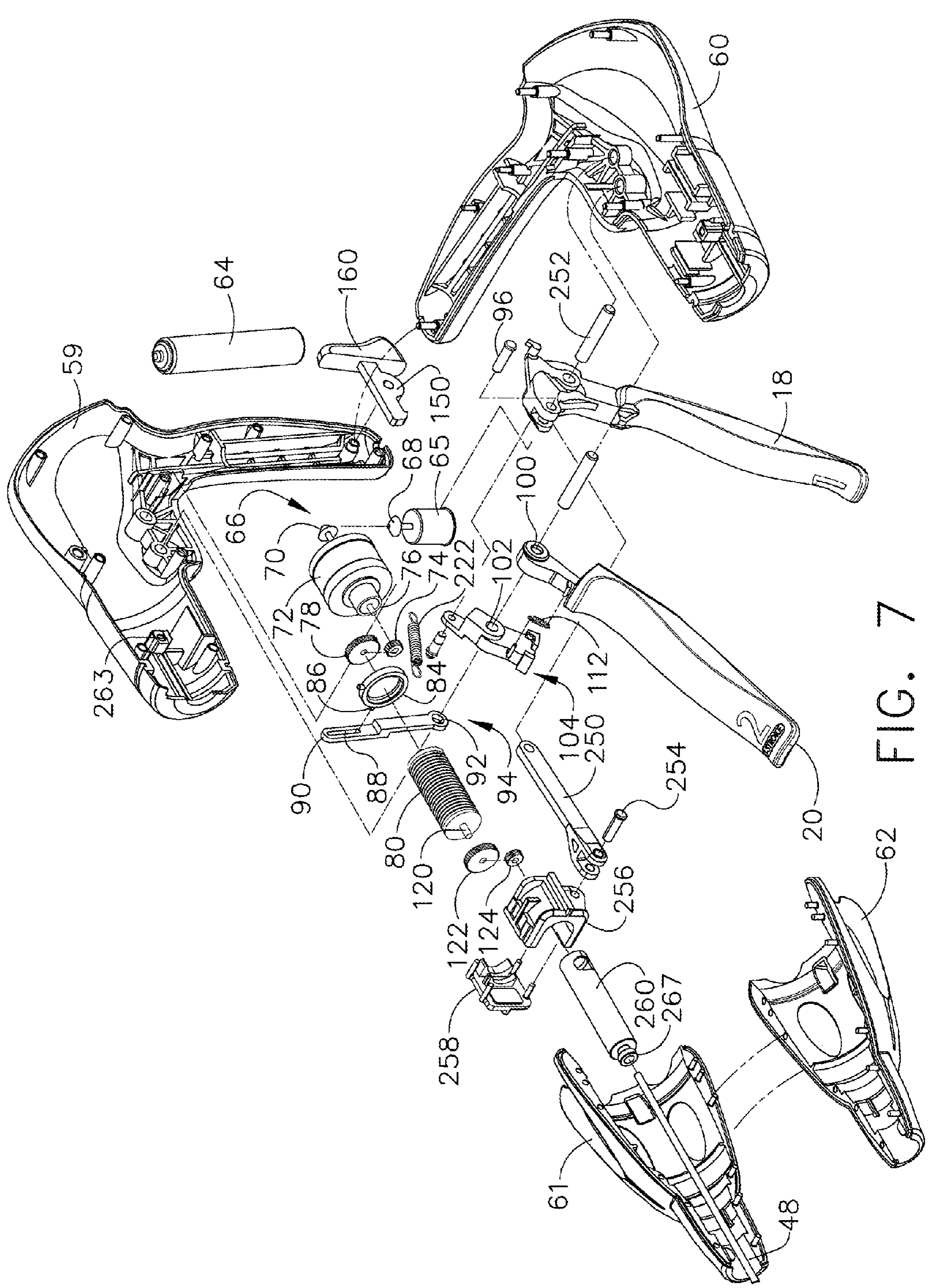


FIG. 6



59
64
160
60
150
96
252
68
65
66
100
18
70
76
74
222
102
72
78
112
86
84
104
2
90
88
92
94
250
20
254
80
120
256
122
124
62
260
267
258
61
48
263

FIG. 7

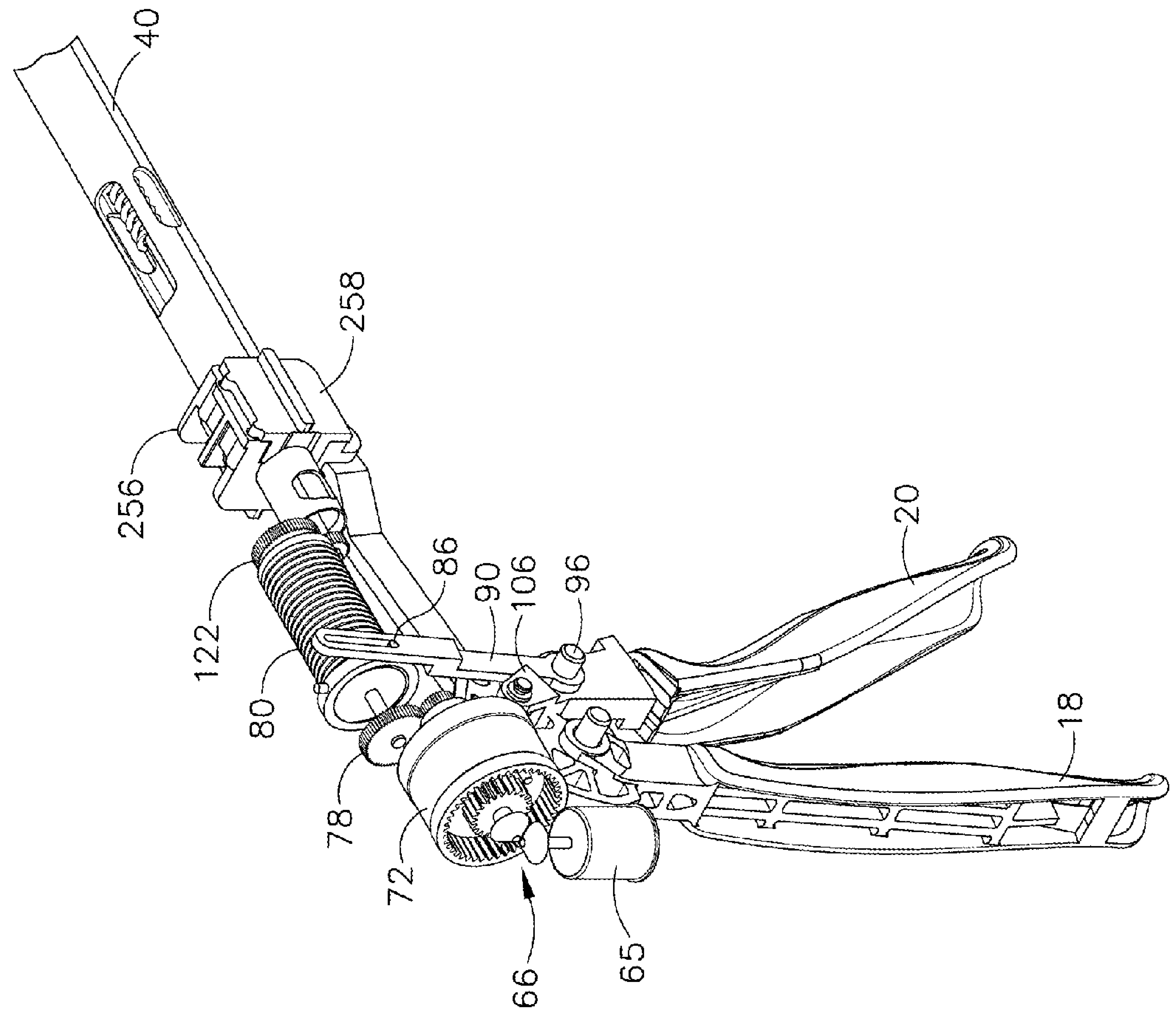


FIG. 8

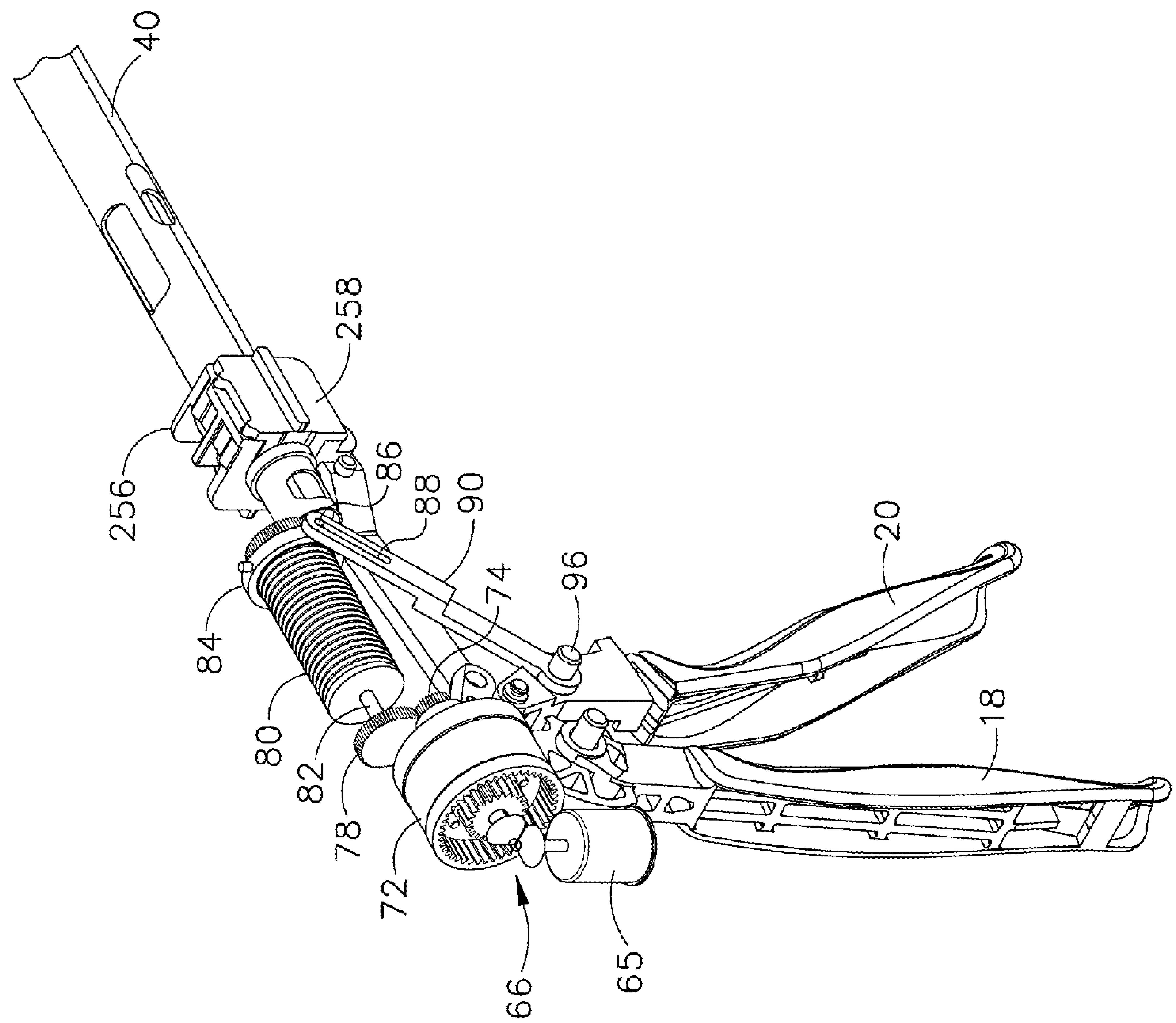


FIG. 9

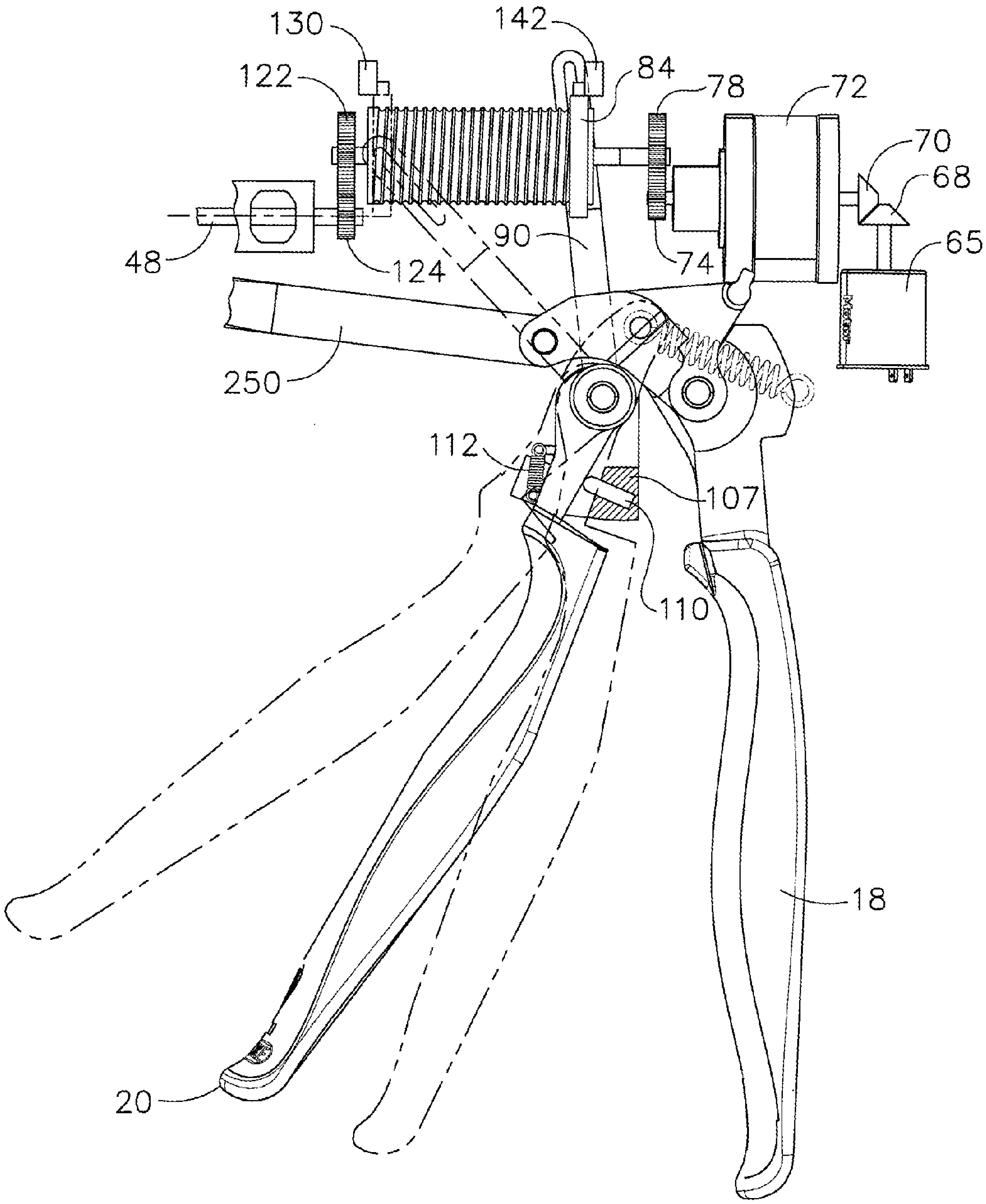


FIG. 10

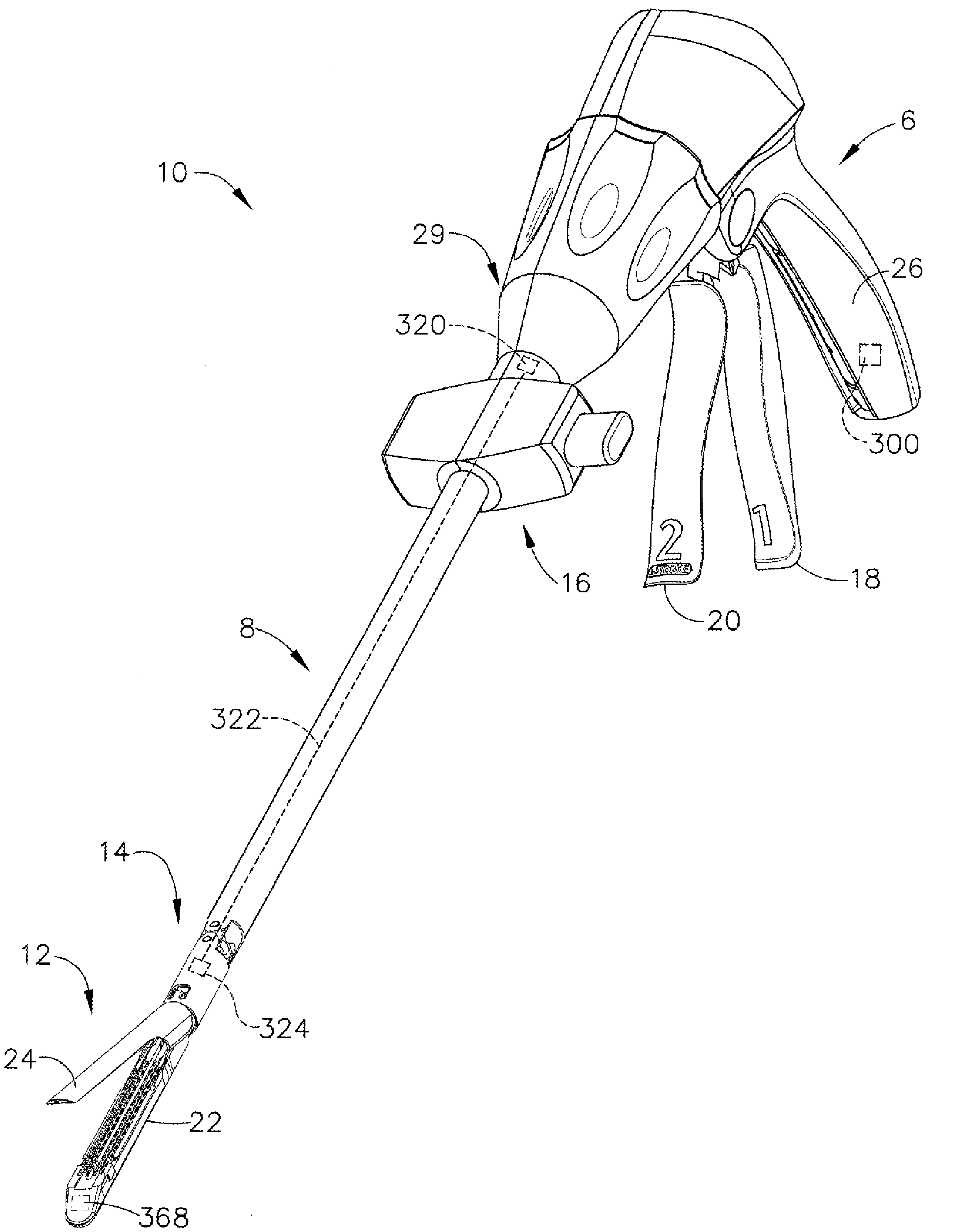


FIG. 11

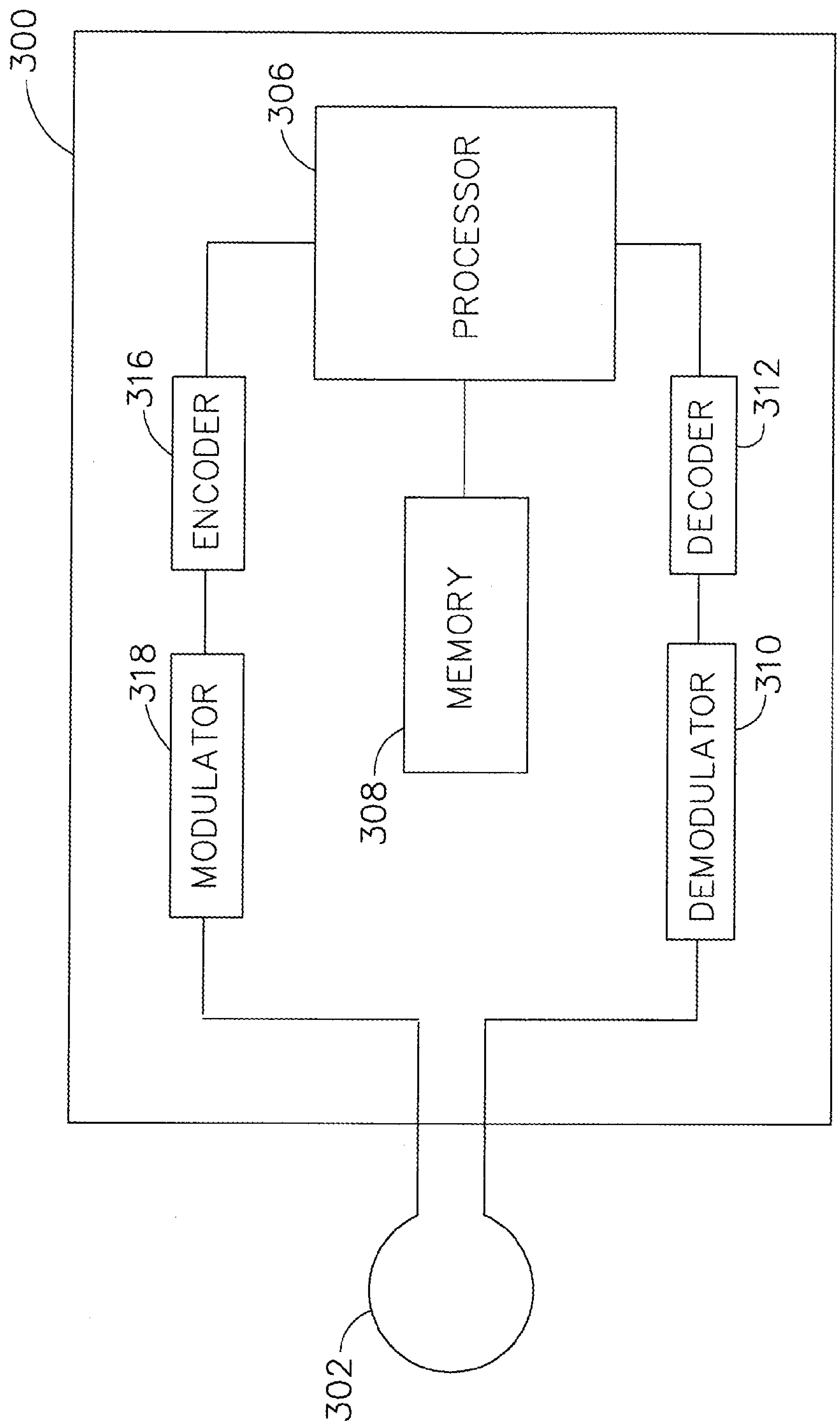

300
306
PROCESSOR
316
ENCODER
312
DECODER
308
MEMORY
318
MODULATOR
310
DEMODULATOR
302

FIG. 12

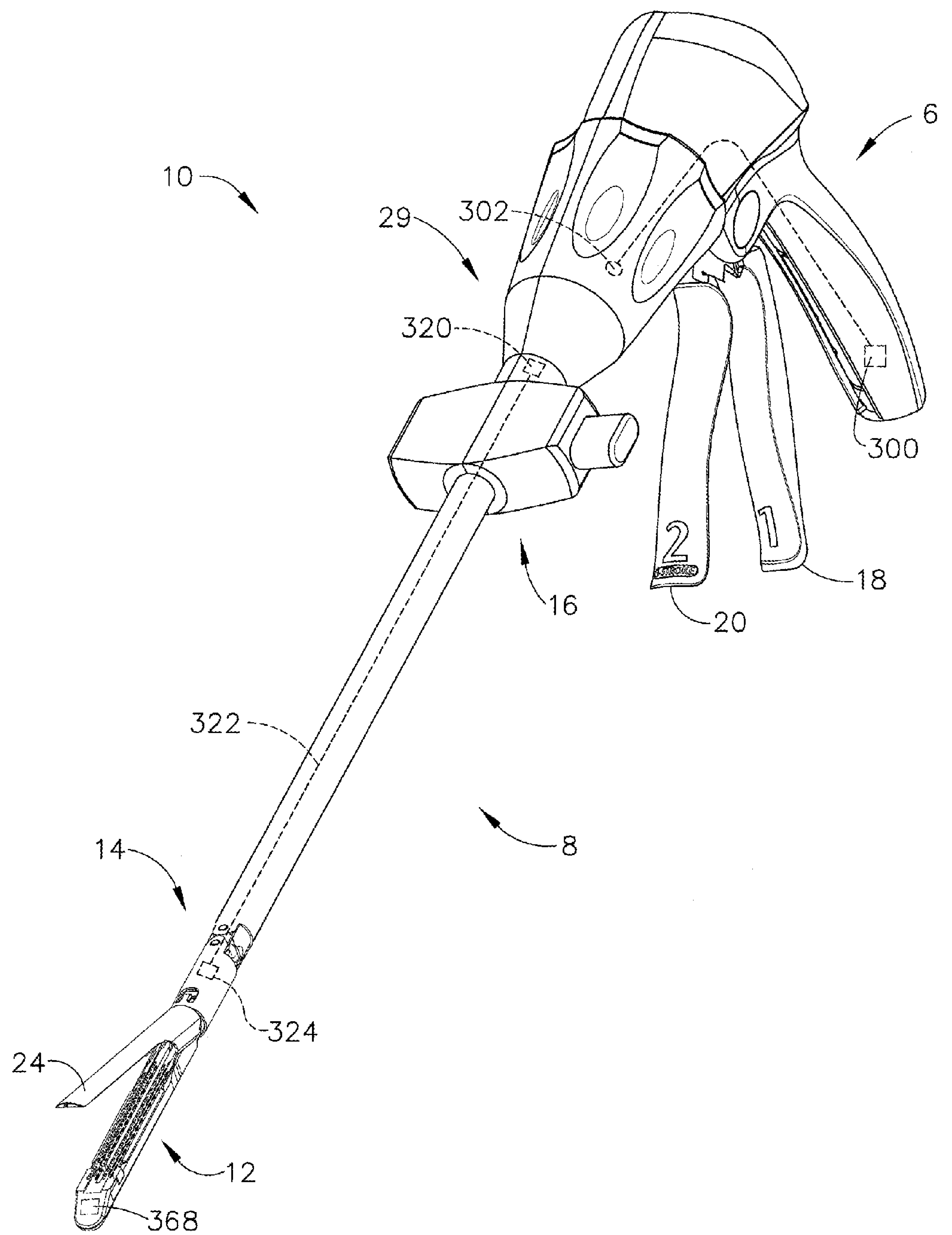


FIG. 13

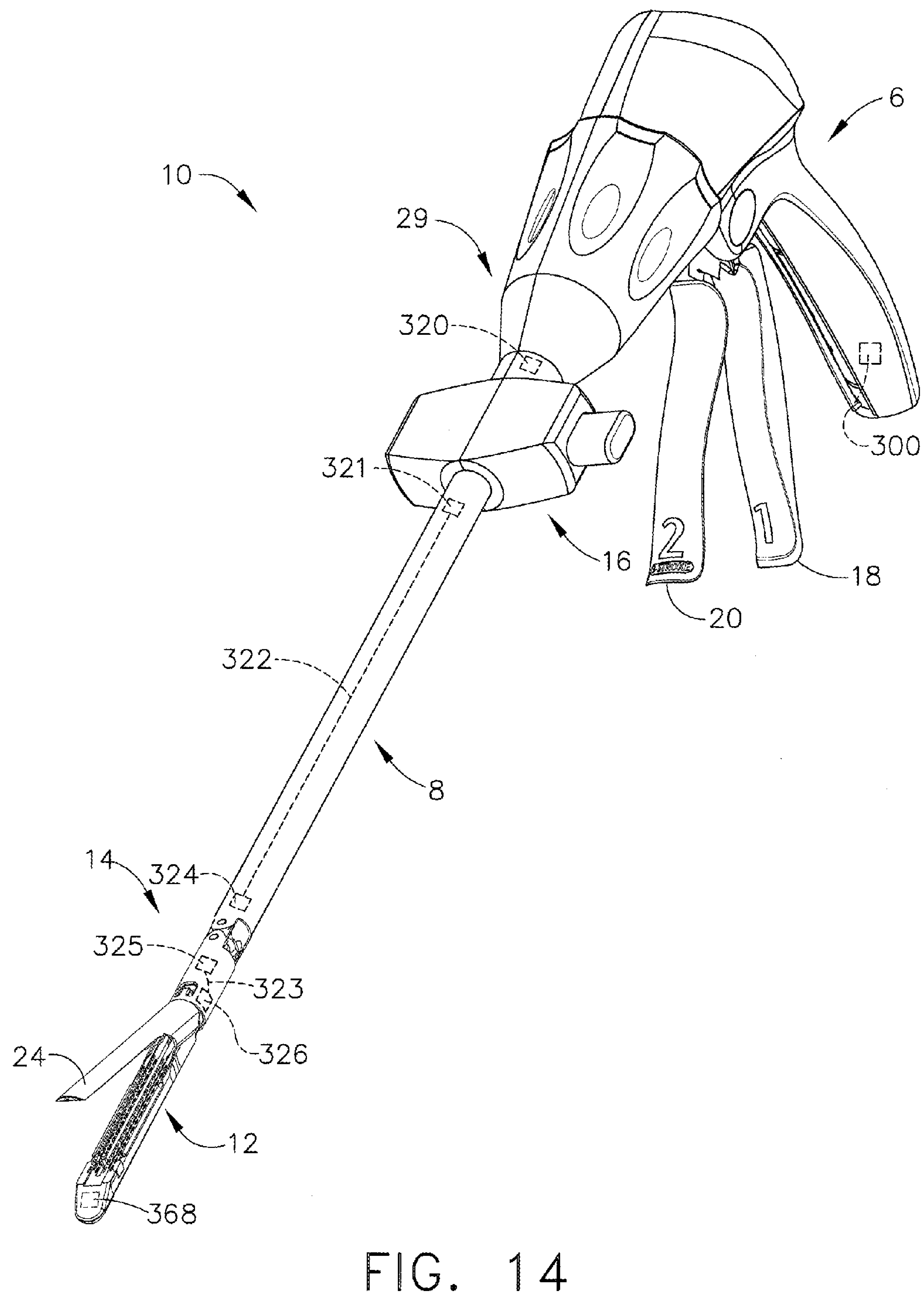


FIG. 14

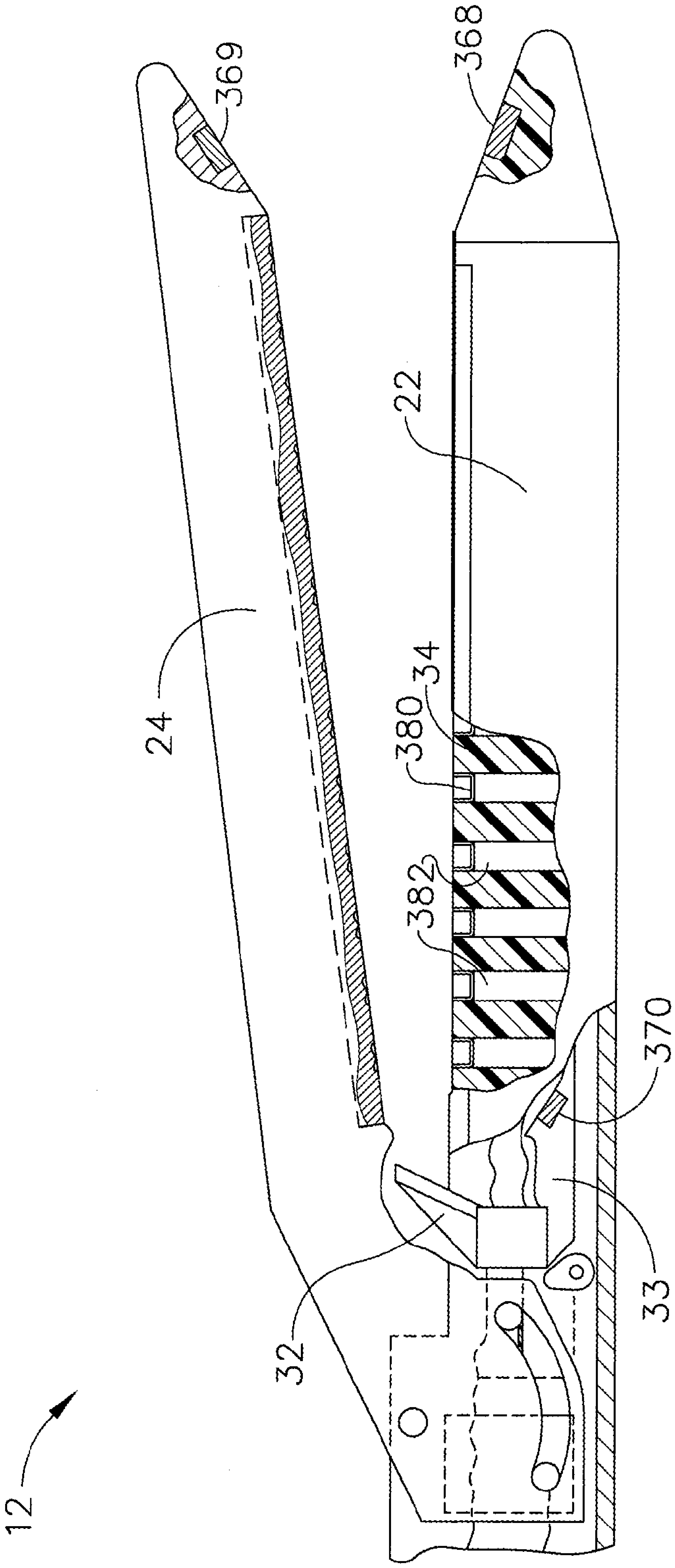


FIG. 15

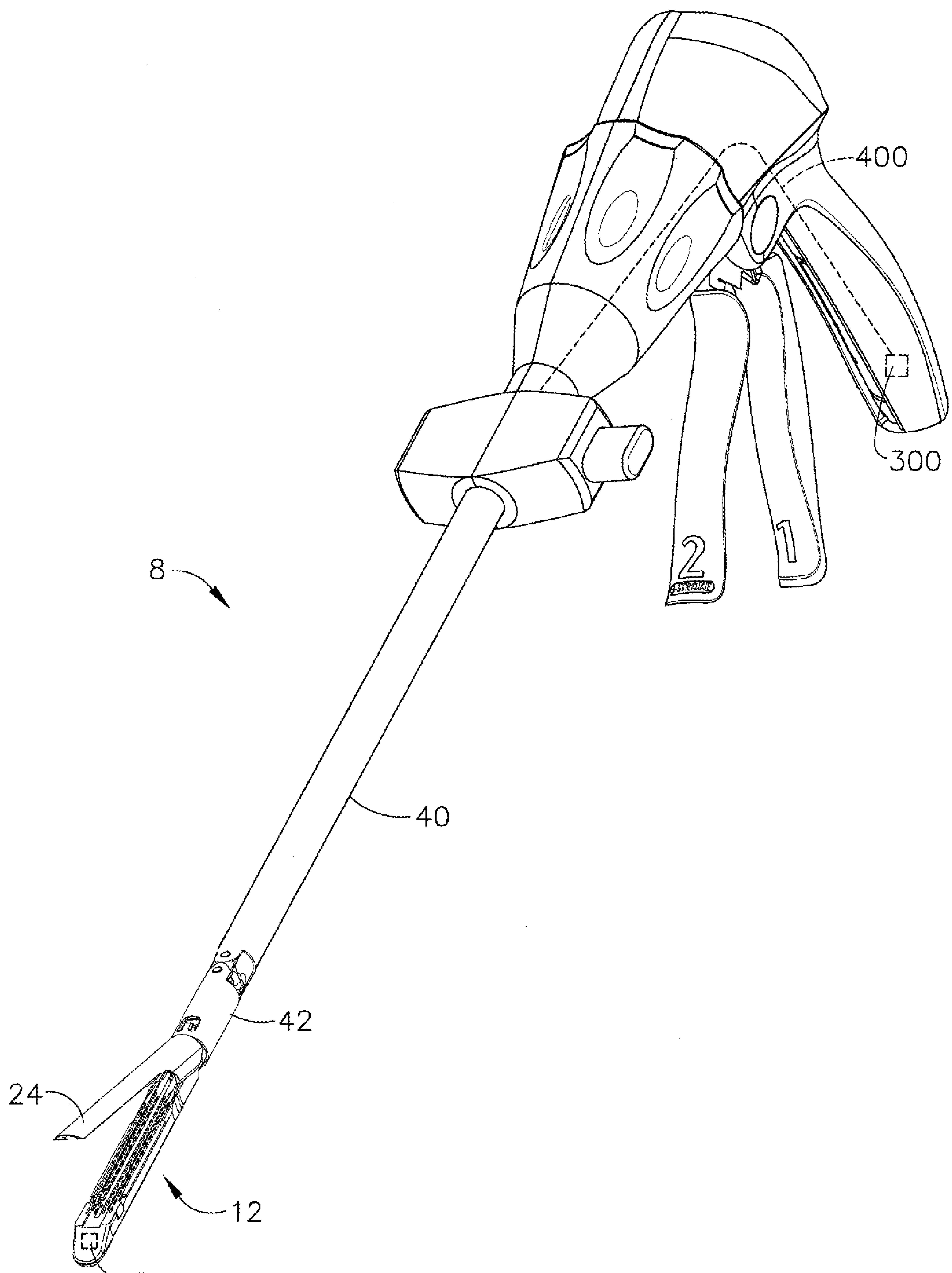


FIG. 16

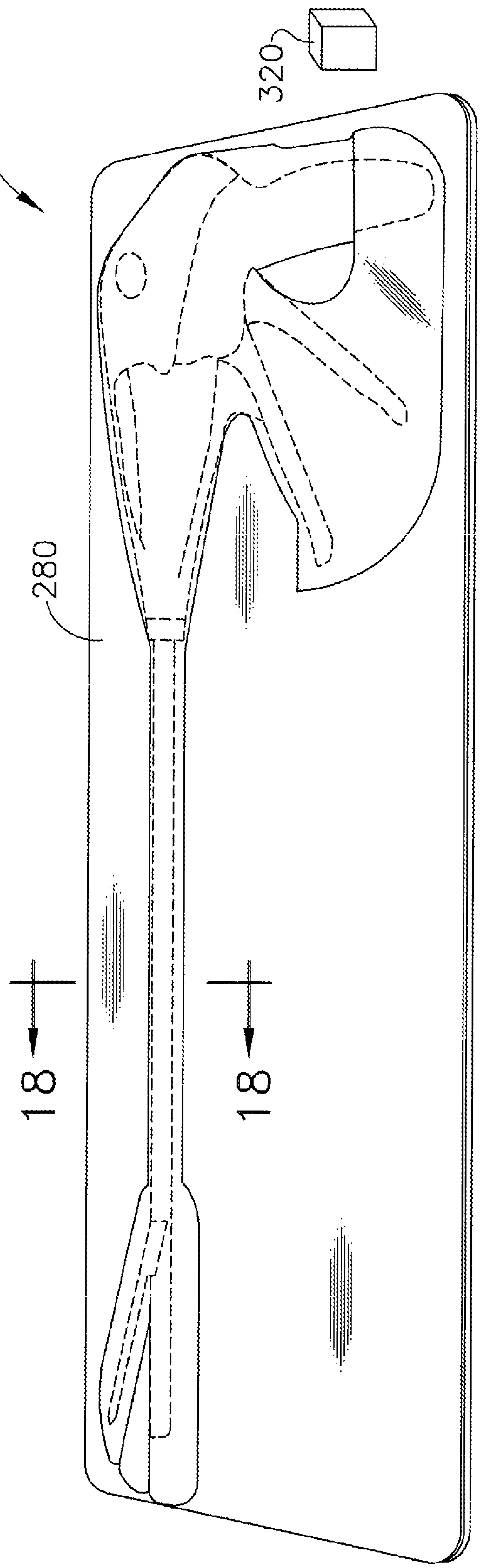


FIG. 17

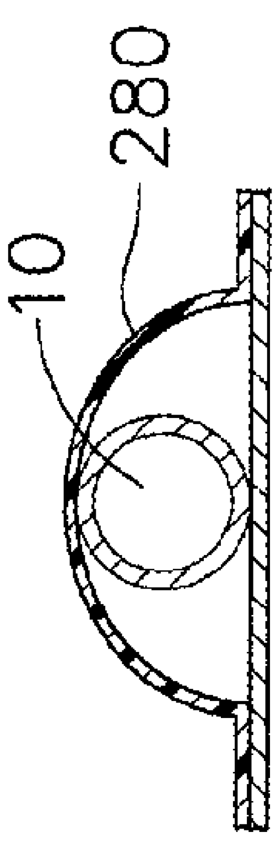


FIG. 18

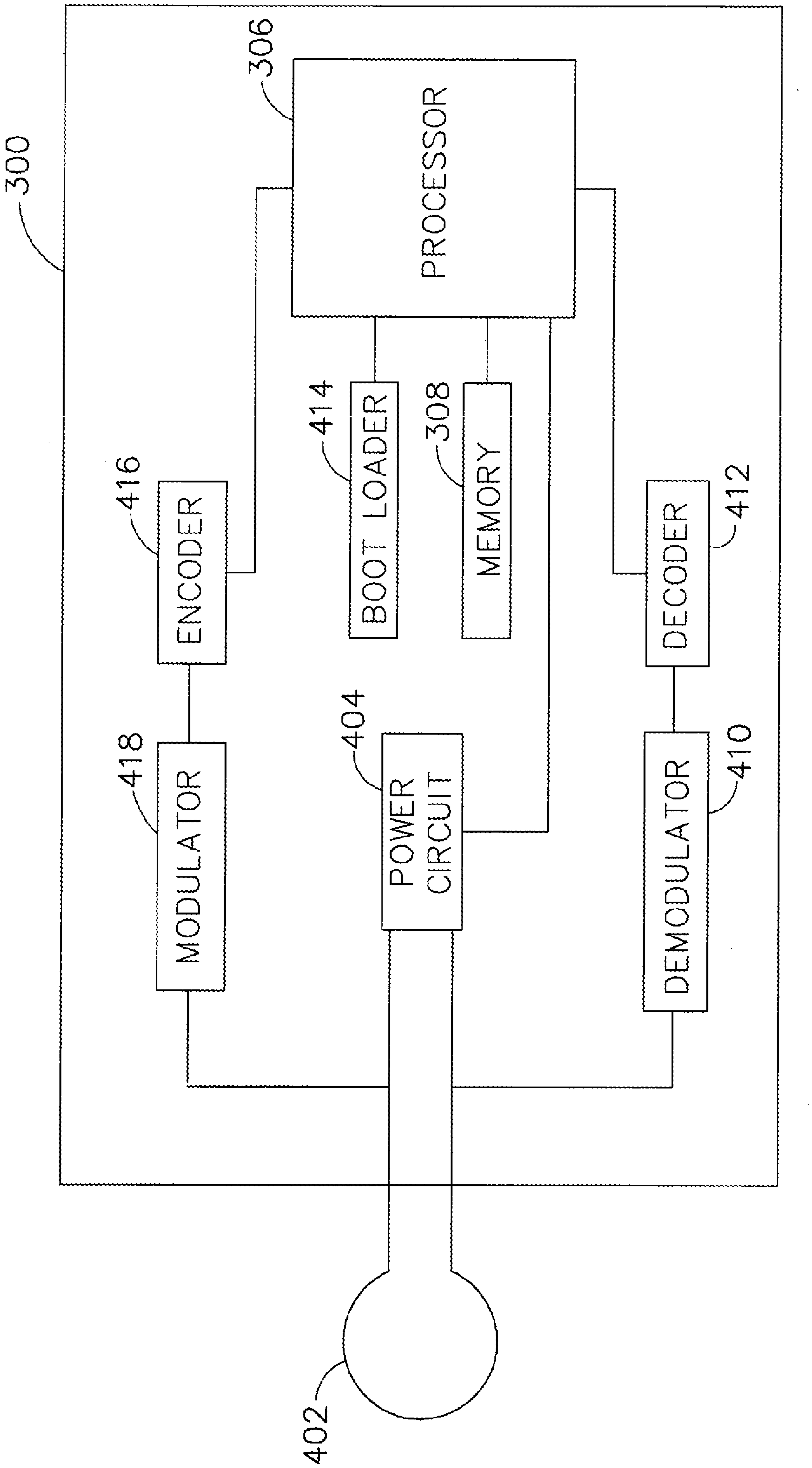

300
306
PROCESSOR
414
BOOT LOADER
308
MEMORY
416
ENCODER
412
DECODER
418
MODULATOR
404
POWER CIRCUIT
410
DEMODULATOR
402

FIG. 19

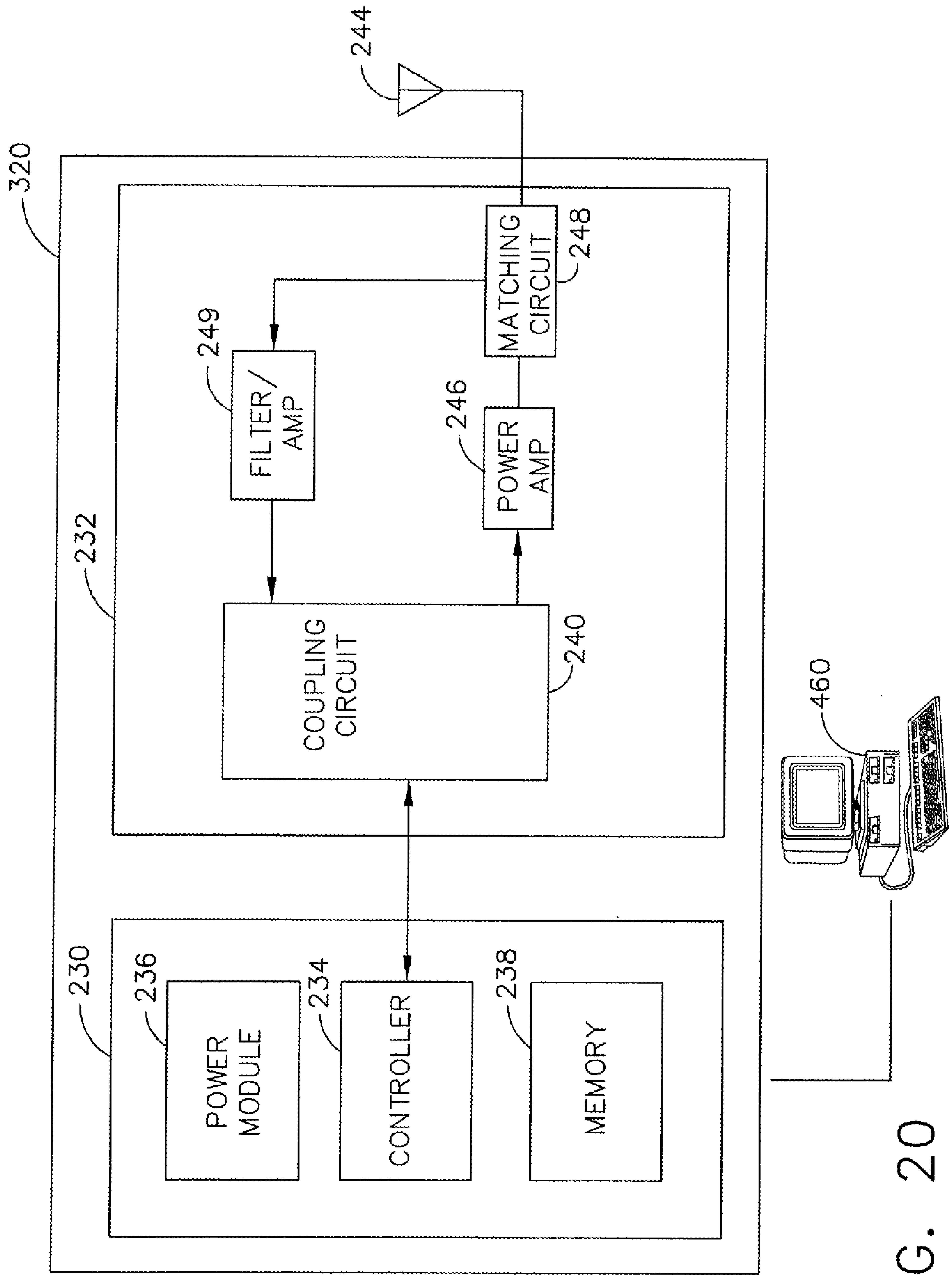

244
320
MATCHING CIRCUIT
248
249
FILTER/ AMP
246
POWER AMP
232
COUPLING CIRCUIT
240
460
230
236
POWER MODULE
234
CONTROLLER
238
MEMORY

FIG. 20

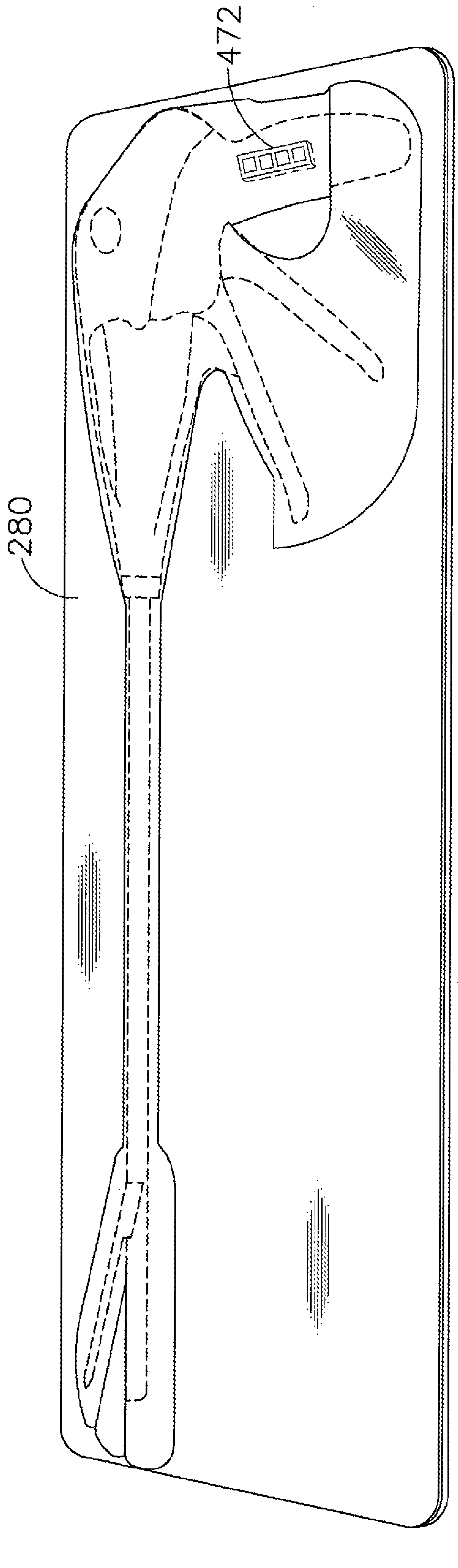


FIG. 21

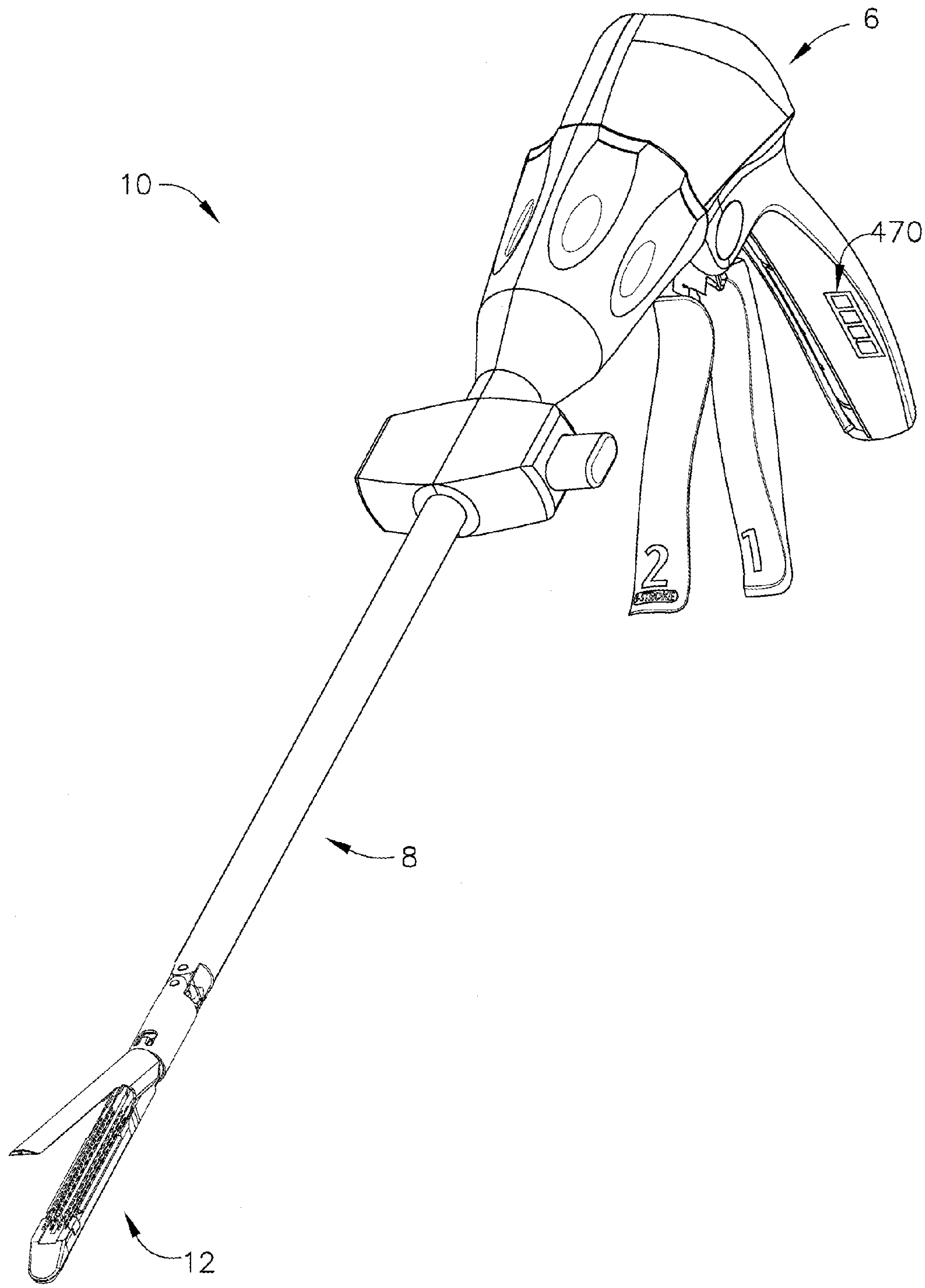


FIG. 22

SURGICAL INSTRUMENT WITH WIRELESS COMMUNICATION BETWEEN CONTROL UNIT AND REMOTE SENSOR

CROSS REFERENCE TO RELATED APPLICATIONS

The present application is related to the following, concurrently-filed U.S. patent applications, which are incorporated herein by reference:

(1) U.S. patent application Ser. No. 11/651,715, entitled "SURGICAL INSTRUMENT WITH WIRELESS COMMUNICATION BETWEEN CONTROL UNIT AND SENSOR TRANSPONDERS," by J. Giordano et al.;

(2) U.S. patent application Ser. No. 11/651,806, entitled "SURGICAL INSTRUMENT WITH ELEMENTS TO COMMUNICATE BETWEEN CONTROL UNIT AND END EFFECTOR," by J. Giordano et al.;

(3) U.S. patent application Ser. No. 11/651,768, entitled "PREVENTION OF CARTRIDGE REUSE IN A SURGICAL INSTRUMENT," by F. Shelton et al.;

(4) U.S. patent application Ser. No. 11/651,771, entitled "POST-STERILIZATION PROGRAMMING OF SURGICAL INSTRUMENTS," by J. Swayze et al.;

(5) U.S. patent application Ser. No. 11/651,788, entitled "INTERLOCK AND SURGICAL INSTRUMENT INCLUDING SAME," by F. Shelton et al.; and

(6) U.S. patent application Ser. No. 11/651,785, entitled "SURGICAL INSTRUMENT WITH ENHANCED BATTERY PERFORMANCE," by F. Shelton et al.

BACKGROUND

Endoscopic surgical instruments are often preferred over traditional open surgical devices since a smaller incision tends to reduce the post-operative recovery time and complications. Consequently, significant development has gone into a range of endoscopic surgical instruments that are suitable for precise placement of a distal end effector at a desired surgical site through a cannula of a trocar. These distal end effectors engage the tissue in a number of ways to achieve a diagnostic or therapeutic effect (e.g., endocutter, grasper, cutter, staplers, clip applier, access device, drug/gene therapy delivery device, and energy device using ultrasound, RF, laser, etc.).

Known surgical staplers include an end effector that simultaneously makes a longitudinal incision in tissue and applies lines of staples on opposing sides of the incision. The end effector includes a pair of cooperating jaw members that, if the instrument is intended for endoscopic or laparoscopic applications, are capable of passing through a cannula passageway. One of the jaw members receives a staple cartridge having at least two laterally spaced rows of staples. The other jaw member defines an anvil having staple-forming pockets aligned with the rows of staples in the cartridge. The instrument includes a plurality of reciprocating wedges which, when driven distally, pass through openings in the staple cartridge and engage drivers supporting the staples to effect the firing of the staples toward the anvil.

An example of a surgical stapler suitable for endoscopic applications is described in U.S. Pat. No. 5,465,895, which discloses an endocutter with distinct closing and firing actions. A clinician using this device is able to close the jaw members upon tissue to position the tissue prior to firing. Once the clinician has determined that the jaw members are properly gripping tissue, the clinician can then fire the surgical stapler with a single firing stroke, thereby severing and stapling the tissue. The simultaneous severing and stapling avoids complications that may arise when performing such actions sequentially with different surgical tools that respectively only sever and staple.

One specific advantage of being able to close upon tissue before firing is that the clinician is able to verify via an endoscope that the desired location for the cut has been achieved, including that a sufficient amount of tissue has been captured between opposing jaws. Otherwise, opposing jaws may be drawn too close together, especially pinching at their distal ends, and thus not effectively forming closed staples in the severed tissue. At the other extreme, an excessive amount of clamped tissue may cause binding and an incomplete firing.

Endoscopic staplers/cutters continue to increase in complexity and function with each generation. One of the main reasons for this is the quest to lower force-to-fire (FTF) to a level that all or a great majority of surgeons can handle. One known solution to lower FTF it use CO_2 or electrical motors. These devices have not faired much better than traditional hand-powered devices, but for a different reason. Surgeons typically prefer to experience proportionate force distribution to that being experienced by the end effector in the forming of the staple to assure them that the cutting/stapling cycle is complete, with the upper limit within the capabilities of most surgeons (usually around 15-30 lbs). They also typically want to maintain control of deploying the staples and being able to stop at anytime if the forces felt in the handle of the device feel too great or for some other clinical reason.

To address this need, so-called "power-assist" endoscopic surgical instruments have been developed in which a supplemental power source aids in the firing of the instrument. For example, in some power-assist devices, a motor provides supplemental electrical power to the power input by the user from squeezing the firing trigger. Such devices are capable of providing loading force feedback and control to the operator to reduce the firing force required to be exerted by the operator in order to complete the cutting operation. One such power-assist device is described in U.S. patent application Ser. No. 11/343,573, filed Jan. 31, 2006 by Shelton et al., entitled "Motor-driven surgical cutting and fastening instrument with loading force feedback," ("the '573 application") which is incorporated herein by reference.

These power-assist devices often include other components that purely mechanical endoscopic surgical instruments do not, such as sensors and control systems. One challenge in using such electronics in a surgical instrument is delivering power and/or data to and from the sensors, particularly when there is a free rotating joint in the surgical instrument.

SUMMARY

In one general aspect, the present invention is directed to a surgical instrument, such as an endoscopic or laparoscopic instrument. According to one embodiment, the surgical instrument comprises an end effector comprising at least one sensor transponder that is passively powered. The surgical instrument also comprises a shaft having a distal end connected to the end effector and a handle connected to a proximate end of the shaft. The handle comprises a control unit (e.g., a microcontroller) that is in communication with the sensor transponder via at least one inductive coupling. Further, the surgical instrument may comprise a rotational joint for rotating the shaft. In such a case, the surgical instrument may comprise a first inductive element located in the shaft distally from the rotational joint and inductively coupled to the control unit, and a second inductive element located distally in the shaft and inductively coupled to the at least one sensor transponder. The first and second inductive elements may be connected by a wired, physical connection.

That way, the control unit may communicate with the transponder in the end effector without a direct wired connection through complex mechanical joints like the rotating joint where it may be difficult to maintain such a wired connection. In addition, because the distances between the inductive elements may be fixed and known, the couplings could be optimized for inductive transfer of energy. Also, the distances could be relatively short so that relatively low power signals could be used to thereby minimize interference with other systems in the use environment of the instrument.

In another general aspect of the present invention, the electrically conductive shaft of the surgical instrument may serve as an antenna for the control unit to wirelessly communicate signals to and from the sensor transponder. For example, the sensor transponder could be located on or disposed in a nonconductive component of the end effector, such as a plastic cartridge, thereby insulating the sensor from conductive components of the end effector and the shaft. In addition, the control unit in the handle may be electrically coupled to the shaft. In that way, the shaft and/or the end effector may serve as an antenna for the control unit by radiating signals from the control unit to the sensor and/or by receiving radiated signals from the sensor. Such a design is particularly useful in surgical instruments having complex mechanical joints (such as rotary joints), which make it difficult to use a direct wired connection between the sensor and control unit for communicating data signals.

In another embodiment, the shaft and/or components of the end effector could serve as the antenna for the sensor by radiating signals to the control unit and receiving radiated signals from the control unit. According to such an embodiment, the control unit is electrically insulated from the shaft and the end effector.

In another general aspect, the present invention is directed to a surgical instrument comprising a programmable control unit that can be programmed by a programming device after the instrument has been packaged and sterilized. In one such embodiment, the programming device may wirelessly program the control unit. The control unit may be passively powered by the wireless signals from the programming device during the programming operation. In another embodiment, the sterile container may comprise a connection interface so that the programming unit can be connected to the surgical instrument while the surgical instrument is in its sterilized container.

FIGURES

Various embodiments of the present invention are described herein by way of example in conjunction with the following figures wherein:

FIGS. **1** and **2** are perspective views of a surgical instrument according to various embodiments of the present invention;

FIGS. **3-5** are exploded views of an end effector and shaft of the instrument according to various embodiments of the present invention;

FIG. **6** is a side view of the end effector according to various embodiments of the present invention;

FIG. **7** is an exploded view of the handle of the instrument according to various embodiments of the present invention;

FIGS. **8** and **9** are partial perspective views of the handle according to various embodiments of the present invention;

FIG. **10** is a side view of the handle according to various embodiments of the present invention;

FIGS. **11**, **13-14**, **16**, and **22** are perspective views of a surgical instrument according to various embodiments of the present invention;

FIGS. **12** and **19** are block diagrams of a control unit according to various embodiments of the present invention;

FIG. **15** is a side view of an end effector including a sensor transponder according to various embodiments of the present invention;

FIGS. **17** and **18** show the instrument in a sterile container according to various embodiments of the present invention;

FIG. **20** is a block diagram of the remote programming device according to various embodiments of the present invention; and

FIG. **21** is a diagram of a packaged instrument according to various embodiments of the present invention.

DETAILED DESCRIPTION

Various embodiments of the present invention are directed generally to a surgical instrument having at least one remote sensor transponder and means for communicating power and/or data signals to the transponder(s) from a control unit. The present invention may be used with any type of surgical instrument comprising at least one sensor transponder, such as endoscopic or laparoscopic surgical instruments, but is particularly useful for surgical instruments where some feature of the instrument, such as a free rotating joint, prevents or otherwise inhibits the use of a wired connection to the sensor(s). Before describing aspects of the system, one type of surgical instrument in which embodiments of the present invention may be used—an endoscopic stapling and cutting instrument (i.e., an endocutter)—is first described by way of illustration.

FIGS. **1** and **2** depict an endoscopic surgical instrument **10** that comprises a handle **6**, a shaft **8**, and an articulating end effector **12** pivotally connected to the shaft **8** at an articulation pivot **14**. Correct placement and orientation of the end effector **12** may be facilitated by controls on the hand **6**, including (1) a rotation knob **28** for rotating the closure tube (described in more detail below in connection with FIGS. **4-5**) at a free rotating joint **29** of the shaft **8** to thereby rotate the end effector **12** and (2) an articulation control **16** to effect rotational articulation of the end effector **12** about the articulation pivot **14**. In the illustrated embodiment, the end effector **12** is configured to act as an endocutter for clamping, severing and stapling tissue, although in other embodiments, different types of end effectors may be used, such as end effectors for other types of surgical instruments, such as graspers, cutters, staplers, clip appliers, access devices, drug/gene therapy devices, ultrasound, RF or laser devices, etc.

The handle **6** of the instrument **10** may include a closure trigger **18** and a firing trigger **20** for actuating the end effector **12**. It will be appreciated that instruments having end effectors directed to different surgical tasks may have different numbers or types of triggers or other suitable controls for operating the end effector **12**. The end effector **12** is shown separated from the handle **6** by the preferably elongate shaft **8**. In one embodiment, a clinician or operator of the instrument **10** may articulate the end effector **12** relative to the shaft **8** by utilizing the articulation control **16**, as described in more detail in pending U.S. patent application Ser. No. 11/329,020, filed Jan. 10, 2006, entitled "Surgical Instrument Having An Articulating End Effector," by Geoffrey C. Hueil et al., which is incorporated herein by reference.

The end effector **12** includes in this example, among other things, a staple channel **22** and a pivotally translatable clamping member, such as an anvil **24**, which are maintained at a spacing that assures effective stapling and severing of tissue clamped in the end effector **12**. The handle **6** includes a pistol grip **26** towards which a closure trigger **18** is pivotally drawn by the clinician to cause clamping or closing of the anvil **24** toward the staple channel **22** of the end effector **12** to thereby clamp tissue positioned between the anvil **24** and channel **22**. The firing trigger **20** is farther outboard of the closure trigger **18**. Once the closure trigger **18** is locked in the closure position, the firing trigger **20** may rotate slightly toward the pistol grip **26** so that it can be reached by the operator using one hand. Then the operator may pivotally draw the firing trigger **20** toward the pistol grip **12** to cause the stapling and severing of clamped tissue in the end effector **12**. The '573 application describes various configurations for locking and unlocking the closure trigger **18**. In other embodiments, different types of clamping members besides the anvil **24** could be used, such as, for example, an opposing jaw, etc.

It will be appreciated that the terms "proximal" and "distal" are used herein with reference to a clinician gripping the handle **6** of an instrument **10**. Thus, the end effector **12** is distal with respect to the more proximal handle **6**. It will be further appreciated that, for convenience and clarity, spatial terms such as "vertical" and "horizontal" are used herein with respect to the drawings. However, surgical instruments are used in many orientations and positions, and these terms are not intended to be limiting and absolute.

The closure trigger **18** may be actuated first. Once the clinician is satisfied with the positioning of the end effector **12**, the clinician may draw back the closure trigger **18** to its fully closed, locked position proximate to the pistol grip **26**. The firing trigger **20** may then be actuated. The firing trigger **20** returns to the open position (shown in FIGS. **1** and **2**) when the clinician removes pressure. A release button **30** on the handle **6**, and in this example, on the pistol grip **26** of the handle, when depressed may release the locked closure trigger **18**.

FIG. **3** is an exploded view of the end effector **12** according to various embodiments. As shown in the illustrated embodiment, the end effector **12** may include, in addition to the previously-mentioned channel **22** and anvil **24**, a cutting instrument **32**, a sled **33**, a staple cartridge **34** that is removably seated in the channel **22**, and a helical screw shaft **36**. The cutting instrument **32** may be, for example, a knife. The anvil **24** may be pivotably opened and closed at a pivot point **25** connected to the proximate end of the channel **22**. The anvil **24** may also include a tab **27** at its proximate end that is inserted into a component of the mechanical closure system (described further below) to open and close the anvil **24**. When the closure trigger **18** is actuated, that is, drawn in by a user of the instrument **10**, the anvil **24** may pivot about the pivot point **25** into the clamped or closed position. If clamping of the end effector **12** is satisfactory, the operator may actuate the firing trigger **20**, which, as explained in more detail below, causes the knife **32** and sled **33** to travel longitudinally along the channel **22**, thereby cutting tissue clamped within the end effector **12**. The movement of the sled **33** along the channel **22** causes the staples of the staple cartridge **34** to be driven through the severed tissue and against the closed anvil **24**, which turns the staples to fasten the severed tissue. U.S. Pat. No. 6,978,921, entitled "Surgical stapling instrument incorporating an E-beam firing mechanism," which is incorporated herein by reference, provides more details about such two-stroke cutting and fastening instruments. The sled **33** may be part of the cartridge **34**, such that when the knife **32** retracts following the cutting operation, the sled **33** does not retract. The channel **22** and the anvil **24** may be made of an electrically conductive material (such as metal) so that they may serve as part of the antenna that communicates with the sensor(s) in the end effector, as described further below. The cartridge **34** could be made of a nonconductive material (such as plastic) and the sensor may be connected to or disposed in the cartridge **34**, as described further below.

It should be noted that although the embodiments of the instrument **10** described herein employ an end effector **12** that staples the severed tissue, in other embodiments different techniques for fastening or sealing the severed tissue may be used. For example, end effectors that use RF energy or adhesives to fasten the severed tissue may also be used. U.S. Pat. No. 5,709,680, entitled "Electrosurgical Hemostatic Device" to Yates et al., and U.S. Pat. No. 5,688,270, entitled "Electrosurgical Hemostatic Device With Recessed And/Or Offset Electrodes" to Yates et al., which are incorporated herein by reference, discloses cutting instruments that use RF energy to fasten the severed tissue. U.S. patent application Ser. No. 11/267,811 to Morgan et al. and U.S. patent application Ser. No. 11/267,383 to Shelton et al., which are also incorporated herein by reference, disclose cutting instruments that use adhesives to fasten the severed tissue. Accordingly, although the description herein refers to cutting/stapling operations and the like, it should be recognized that this is an exemplary embodiment and is not meant to be limiting. Other tissue-fastening techniques may also be used.

FIGS. **4** and **5** are exploded views and FIG. **6** is a side view of the end effector **12** and shaft **8** according to various embodiments. As shown in the illustrated embodiment, the shaft **8** may include a proximate closure tube **40** and a distal closure tube **42** pivotably linked by a pivot links **44**. The distal closure tube **42** includes an opening **45** into which the tab **27** on the anvil **24** is inserted in order to open and close the anvil **24**. Disposed inside the closure tubes **40**, **42** may be a proximate spine tube **46**. Disposed inside the proximate spine tube **46** may be a main rotational (or proximate) drive shaft **48** that communicates with a secondary (or distal) drive shaft **50** via a bevel gear assembly **52**. The secondary drive shaft **50** is connected to a drive gear **54** that engages a proximate drive gear **56** of the helical screw shaft **36**. The vertical bevel gear **52*b*** may sit and pivot in an opening **57** in the distal end of the proximate spine tube **46**. A distal spine tube **58** may be used to enclose the secondary drive shaft **50** and the drive gears **54**, **56**. Collectively, the main drive shaft **48**, the secondary drive shaft **50**, and the articulation assembly (e.g., the bevel gear assembly **52*a-c***), are sometimes referred to herein as the "main drive shaft assembly." The closure tubes **40**, **42** may be made of electrically conductive material (such as metal) so that they may serve as part of the antenna, as described further below. Components of the main drive shaft assembly (e.g., the drive shafts **48**, **50**) may be made of a nonconductive material (such as plastic).

A bearing **38**, positioned at a distal end of the staple channel **22**, receives the helical drive screw **36**, allowing the helical drive screw **36** to freely rotate with respect to the channel **22**. The helical screw shaft **36** may interface a threaded opening (not shown) of the knife **32** such that rotation of the shaft **36** causes the knife **32** to translate distally or proximately (depending on the direction of the rotation) through the staple channel **22**. Accordingly, when the main drive shaft **48** is caused to rotate by actuation of the firing trigger **20** (as explained in more detail below), the bevel gear assembly **52*a-c*** causes the secondary drive shaft **50** to rotate, which in turn, because of the engagement of the drive gears **54**, **56**, causes the helical screw shaft **36** to rotate, which causes the knife **32** to travel longitudinally along the channel **22** to cut any tissue clamped within the end effector. The sled **33** may be made of, for example, plastic, and may have a sloped distal surface. As the sled **33** traverses the channel **22**, the sloped forward surface may push up or drive the staples in the staple cartridge **34** through the clamped tissue and against the anvil **24**. The anvil **24** turns the staples, thereby stapling the severed tissue. When the knife **32** is retracted, the knife **32** and sled **33** may become disengaged, thereby leaving the sled **33** at the distal end of the channel **22**.

According to various embodiments, as shown FIGS. **7-10**, the surgical instrument may include a battery **64** in the handle **6**. The illustrated embodiment provides user-feedback regarding the deployment and loading force of the cutting instrument in the end effector **12**. In addition, the embodiment may use power provided by the user in retracting the firing trigger **18** to power the instrument **10** (a so-called "power assist" mode). As shown in the illustrated embodiment, the handle **6** includes exterior lower side pieces **59**, **60** and exterior upper side pieces **61**, **62** that fit together to form, in general, the exterior of the handle **6**. The handle pieces **59-62** may be made of an electrically nonconductive material, such as plastic. A battery **64** may be provided in the pistol grip portion **26** of the handle **6**. The battery **64** powers a motor **65** disposed in an upper portion of the pistol grip portion **26** of the handle **6**. The battery **64** may be constructed according to any suitable construction or chemistry including, for example, a Li-ion chemistry such as $LiCoO_2$ or $LiNiO_2$, a Nickel Metal Hydride chemistry, etc. According to various embodiments, the motor **65** may be a DC brushed driving motor having a maximum rotation of, approximately, 5000 RPM to 100,000 RPM. The motor **64** may drive a 90° bevel gear assembly **66** comprising a first bevel gear **68** and a second bevel gear **70**. The bevel gear assembly **66** may drive a planetary gear assembly **72**. The planetary gear assembly **72** may include a pinion gear **74** connected to a drive shaft **76**. The pinion gear **74** may drive a mating ring gear **78** that drives a helical gear drum **80** via a drive shaft **82**. A ring **84** may be threaded on the helical gear drum **80**. Thus, when the motor **65** rotates, the ring **84** is caused to travel along the helical gear drum **80** by means of the interposed bevel gear assembly **66**, planetary gear assembly **72** and ring gear **78**.

The handle **6** may also include a run motor sensor **110** in communication with the firing trigger **20** to detect when the firing trigger **20** has been drawn in (or "closed") toward the pistol grip portion **26** of the handle **6** by the operator to thereby actuate the cutting/stapling operation by the end effector **12**. The sensor **110** may be a proportional sensor such as, for example, a rheostat or variable resistor. When the firing trigger **20** is drawn in, the sensor **110** detects the movement, and sends an electrical signal indicative of the voltage (or power) to be supplied to the motor **65**. When the sensor **110** is a variable resistor or the like, the rotation of the motor **65** may be generally proportional to the amount of movement of the firing trigger **20**. That is, if the operator only draws or closes the firing trigger **20** in a little bit, the rotation of the motor **65** is relatively low. When the firing trigger **20** is fully drawn in (or in the fully closed position), the rotation of the motor **65** is at its maximum. In other words, the harder the user pulls on the firing trigger **20**, the more voltage is applied to the motor **65**, causing greater rates of rotation. In another embodiment, for example, the control unit (described further below) may output a PWM control signal to the motor **65** based on the input from the sensor **110** in order to control the motor **65**.

The handle **6** may include a middle handle piece **104** adjacent to the upper portion of the firing trigger **20**. The handle **6** also may comprise a bias spring **112** connected between posts on the middle handle piece **104** and the firing trigger **20**. The bias spring **112** may bias the firing trigger **20** to its fully open position. In that way, when the operator releases the firing trigger **20**, the bias spring **112** will pull the firing trigger **20** to its open position, thereby removing actuation of the sensor **110**, thereby stopping rotation of the motor **65**. Moreover, by virtue of the bias spring **112**, any time a user closes the firing trigger **20**, the user will experience resistance to the closing operation, thereby providing the user with feedback as to the amount of rotation exerted by the motor **65**. Further, the operator could stop retracting the firing trigger **20** to thereby remove force from the sensor **100**, to thereby stop the motor **65**. As such, the user may stop the deployment of the end effector **12**, thereby providing a measure of control of the cutting/fastening operation to the operator.

The distal end of the helical gear drum **80** includes a distal drive shaft **120** that drives a ring gear **122**, which mates with a pinion gear **124**. The pinion gear **124** is connected to the main drive shaft **48** of the main drive shaft assembly. In that way, rotation of the motor **65** causes the main drive shaft assembly to rotate, which causes actuation of the end effector **12**, as described above.

The ring **84** threaded on the helical gear drum **80** may include a post **86** that is disposed within a slot **88** of a slotted arm **90**. The slotted arm **90** has an opening **92** at its opposite end **94** that receives a pivot pin **96** that is connected between the handle exterior side pieces **59**, **60**. The pivot pin **96** is also disposed through an opening **100** in the firing trigger **20** and an opening **102** in the middle handle piece **104**.

In addition, the handle **6** may include a reverse motor (or end-of-stroke sensor) **130** and a stop motor (or beginning-of-stroke) sensor **142**. In various embodiments, the reverse motor sensor **130** may be a limit switch located at the distal end of the helical gear drum **80** such that the ring **84** threaded on the helical gear drum **80** contacts and trips the reverse motor sensor **130** when the ring **84** reaches the distal end of the helical gear drum **80**. The reverse motor sensor **130**, when activated, sends a signal to the control unit which sends a signal to the motor **65** to reverse its rotation direction, thereby withdrawing the knife **32** of the end effector **12** following the cutting operation.

The stop motor sensor **142** may be, for example, a normally-closed limit switch. In various embodiments, it may be located at the proximate end of the helical gear drum **80** so that the ring **84** trips the switch **142** when the ring **84** reaches the proximate end of the helical gear drum **80**.

In operation, when an operator of the instrument **10** pulls back the firing trigger **20**, the sensor **110** detects the deployment of the firing trigger **20** and sends a signal to the control unit which sends a signal to the motor **65** to cause forward rotation of the motor **65** at, for example, a rate proportional to how hard the operator pulls back the firing trigger **20**. The forward rotation of the motor **65** in turn causes the ring gear **78** at the distal end of the planetary gear assembly **72** to rotate, thereby causing the helical gear drum **80** to rotate, causing the ring **84** threaded on the helical gear drum **80** to travel distally along the helical gear drum **80**. The rotation of the helical gear drum **80** also drives the main drive shaft assembly as described above, which in turn causes deployment of the knife **32** in the end effector **12**. That is, the knife **32** and sled **33** are caused to traverse the channel **22** longitudinally, thereby cutting tissue clamped in the end effector **12**. Also, the stapling operation of the end effector **12** is caused to happen in embodiments where a stapling-type end effector is used.

By the time the cutting/stapling operation of the end effector **12** is complete, the ring **84** on the helical gear drum **80** will have reached the distal end of the helical gear drum **80**, thereby causing the reverse motor sensor **130** to be tripped, which sends a signal to the control unit which sends a signal to the motor **65** to cause the motor **65** to reverse its rotation. This in turn causes the knife **32** to retract, and also causes the ring **84** on the helical gear drum **80** to move back to the proximate end of the helical gear drum **80**.

The middle handle piece **104** includes a backside shoulder **106** that engages the slotted arm **90** as best shown in FIGS. **8** and **9**. The middle handle piece **104** also has a forward motion stop **107** that engages the firing trigger **20**. The movement of the slotted arm **90** is controlled, as explained above, by rotation of the motor **65**. When the slotted arm **90** rotates CCW as the ring **84** travels from the proximate end of the helical gear drum **80** to the distal end, the middle handle piece **104** will be free to rotate CCW. Thus, as the user draws in the firing trigger **20**, the firing trigger **20** will engage the forward motion stop **107** of the middle handle piece **104**, causing the middle handle piece **104** to rotate CCW. Due to the backside shoulder **106** engaging the slotted arm **90**, however, the middle handle piece **104** will only be able to rotate CCW as far as the slotted arm **90** permits. In that way, if the motor **65** should stop rotating for some reason, the slotted arm **90** will stop rotating, and the user will not be able to further draw in the firing trigger **20** because the middle handle piece **104** will not be free to rotate CCW due to the slotted arm **90**.

Components of an exemplary closure system for closing (or clamping) the anvil **24** of the end effector **12** by retracting the closure trigger **18** are also shown in FIGS. **7-10**. In the illustrated embodiment, the closure system includes a yoke **250** connected to the closure trigger **18** by a pin **251** that is inserted through aligned openings in both the closure trigger **18** and the yoke **250**. A pivot pin **252**, about which the closure trigger **18** pivots, is inserted through another opening in the closure trigger **18** which is offset from where the pin **251** is inserted through the closure trigger **18**. Thus, retraction of the closure trigger **18** causes the upper part of the closure trigger **18**, to which the yoke **250** is attached via the pin **251**, to rotate CCW. The distal end of the yoke **250** is connected, via a pin **254**, to a first closure bracket **256**. The first closure bracket **256** connects to a second closure bracket **258**. Collectively, the closure brackets **256**, **258** define an opening in which the proximate end of the proximate closure tube **40** (see FIG. **4**) is seated and held such that longitudinal movement of the closure brackets **256**, **258** causes longitudinal motion by the proximate closure tube **40**. The instrument **10** also includes a closure rod **260** disposed inside the proximate closure tube **40**. The closure rod **260** may include a window **261** into which a post **263** on one of the handle exterior pieces, such as exterior lower side piece **59** in the illustrated embodiment, is disposed to fixedly connect the closure rod **260** to the handle **6**. In that way, the proximate closure tube **40** is capable of moving longitudinally relative to the closure rod **260**. The closure rod **260** may also include a distal collar **267** that fits into a cavity **269** in proximate spine tube **46** and is retained therein by a cap **271** (see FIG. **4**).

In operation, when the yoke **250** rotates due to retraction of the closure trigger **18**, the closure brackets **256**, **258** cause the proximate closure tube **40** to move distally (i.e., away from the handle end of the instrument **10**), which causes the distal closure tube **42** to move distally, which causes the anvil **24** to rotate about the pivot point **25** into the clamped or closed position. When the closure trigger **18** is unlocked from the locked position, the proximate closure tube **40** is caused to slide proximately, which causes the distal closure tube **42** to slide proximately, which, by virtue of the tab **27** being inserted in the window **45** of the distal closure tube **42**, causes the anvil **24** to pivot about the pivot point **25** into the open or unclamped position. In that way, by retracting and locking the closure trigger **18**, an operator may clamp tissue between the anvil **24** and channel **22**, and may unclamp the tissue following the cutting/stapling operation by unlocking the closure trigger **18** from the locked position.

The control unit (described further below) may receive the outputs from end-of-stroke and beginning-of-stroke sensors **130**, **142** and the run-motor sensor **110**, and may control the motor **65** based on the inputs. For example, when an operator initially pulls the firing trigger **20** after locking the closure trigger **18**, the run-motor sensor **110** is actuated. If the staple cartridge **34** is present in the end effector **12**, a cartridge lockout sensor (not shown) may be closed, in which case the control unit may output a control signal to the motor **65** to cause the motor **65** to rotate in the forward direction. When the end effector **12** reaches the end of its stroke, the reverse motor sensor **130** will be activated. The control unit may receive this output from the reverse motor sensor **130** and cause the motor **65** to reverse its rotational direction. When the knife **32** is fully retracted, the stop motor sensor switch **142** is activated, causing the control unit to stop the motor **65**.

In other embodiments, rather than a proportional-type sensor **110**, an on-off type sensor could be used. In such embodiments, the rate of rotation of the motor **65** would not be proportional to the force applied by the operator. Rather, the motor **65** would generally rotate at a constant rate. But the operator would still experience force feedback because the firing trigger **20** is geared into the gear drive train.

The instrument **10** may include a number of sensor transponders in the end effector **12** for sensing various conditions related to the end effector **12**, such as sensor transponders for determining the status of the staple cartridge **34** (or other type of cartridge depending on the type of surgical instrument), the progress of the stapler during closure and firing, etc. The sensor transponders may be passively powered by inductive signals, as described further below, although in other embodiments the transponders could be powered by a remote power source, such as a battery in the end effector **12**, for example. The sensor transponder(s) could include magnetoresistive, optical, electromechanical, RFID, MEMS, motion or pressure sensors, for example. These sensor transponders may be in communication with a control unit **300**, which may be housed in the handle **6** of the instrument **10**, for example, as shown in FIG. **11**.

As shown in FIG. **12**, according to various embodiments the control unit **300** may comprise a processor **306** and one or more memory units **308**. By executing instruction code stored in the memory **308**, the processor **306** may control various components of the instrument **10**, such as the motor **65** or a user display (not shown), based on inputs received from the various end effector sensor transponders and other sensor(s) (such as the run-motor sensor **110**, the end-of-stroke sensor **130**, and the beginning-of-stroke sensor **142**, for example). The control unit **300** may be powered by the battery **64** during surgical use of instrument **10**. The control unit **300** may comprise an inductive element **302** (e.g., a coil or antenna) to pick up wireless signals from the sensor transponders, as described in more detail below. Input signals received by the inductive element **302** acting as a receiving antenna may be demodulated by a demodulator **310** and decoded by a decoder **312**. The input signals may comprise data from the sensor transponders in the end effector **12**, which the processor **306** may use to control various aspects of the instrument **10**.

To transmit signals to the sensor transponders, the control unit **300** may comprise an encoder **316** for encoding the signals and a modulator **318** for modulating the signals according to the modulation scheme. The inductive element **302** may act as the transmitting antenna. The control unit **300** may communicate with the sensor transponders using any suitable wireless communication protocol and any suitable frequency (e.g., an ISM band). Also, the control unit **300** may transmit signals at a different frequency range than the frequency range of the received signals from the sensor transponders. Also, although only one antenna (inductive element **302**) is shown in FIG. **12**, in other embodiments the control unit **300** may have separate receiving and transmitting antennas.

According to various embodiments, the control unit **300** may comprise a microcontroller, a microprocessor, a field programmable gate array (FPGA), one or more other types of integrated circuits (e.g., RF receivers and PWM controllers), and/or discrete passive components. The control units may also be embodied as system-on-chip (SoC) or a system-in-package (SIP), for example.

As shown in FIG. **11**, the control unit **300** may be housed in the handle **6** of the instrument **10** and one or more of the sensor transponders **368** for the instrument **10** may be located in the end effector **12**. To deliver power and/or transmit data to or from the sensor transponders **368** in the end effector **12**, the inductive element **302** of the control unit **300** may be inductively coupled to a secondary inductive element (e.g., a coil) **320** positioned in the shaft **8** distally from the rotation joint **29**. The secondary inductive element **320** is preferably electrically insulated from the conductive shaft **8**.

The secondary inductive element **320** may be connected by an electrically conductive, insulated wire **322** to a distal inductive element (e.g., a coil) **324** located near the end effector **12**, and preferably distally relative to the articulation pivot **14**. The wire **322** may be made of an electrically conductive polymer and/or metal (e.g., copper) and may be sufficiently flexible so that it could pass though the articulation pivot **14** and not be damaged by articulation. The distal inductive element **324** may be inductively coupled to the sensor transponder **368** in, for example, the cartridge **34** of the end effector **12**. The transponder **368**, as described in more detail below, may include an antenna (or coil) for inductive coupling to the distal coil **324**, a sensor and integrated control electronics for receiving and transmitting wireless communication signals.

The transponder **368** may use a portion of the power of the inductive signal received from the distal inductive element **326** to passively power the transponder **368**. Once sufficiently powered by the inductive signals, the transponder **368** may receive and transmit data to the control unit **300** in the handle **6** via (i) the inductive coupling between the transponder **368** and the distal inductive element **324**, (ii) the wire **322**, and (iii) the inductive coupling between the secondary inductive element **320** and the control unit **300**. That way, the control unit **300** may communicate with the transponder **368** in the end effector **12** without a direct wired connection through complex mechanical joints like the rotating joint **29** and/or without a direct wired connection from the shaft **8** to the end effector **12**, places where it may be difficult to maintain such a wired connection. In addition, because the distances between the inductive elements (e.g., the spacing between (i) the transponder **368** and the distal inductive element **324**, and (ii) the secondary inductive element **320** and the control unit **300**) and fixed and known, the couplings could be optimized for inductive transfer of energy. Also, the distances could be relatively short so that relatively low power signals could be used to thereby minimize interference with other systems in the use environment of the instrument **10**.

In the embodiment of FIG. **12**, the inductive element **302** of the control unit **300** is located relatively near to the control unit **300**. According to other embodiments, as shown in FIG. **13**, the inductive element **302** of the control unit **300** may be positioned closer to the rotating joint **29** to that it is closer to the secondary inductive element **320**, thereby reducing the distance of the inductive coupling in such an embodiment. Alternatively, the control unit **300** (and hence the inductive element **302**) could be positioned closer to the secondary inductive element **320** to reduce the spacing.

In other embodiments, more or fewer than two inductive couplings may be used. For example, in some embodiments, the surgical instrument **10** may use a single inductive coupling between the control unit **300** in the handle **6** and the transponder **368** in the end effector **12**, thereby eliminating the inductive elements **320**, **324** and the wire **322**. Of course, in such an embodiment, a stronger signal may be required due to the greater distance between the control unit **300** in the handle **6** and the transponder **368** in the end effector **12**. Also, more than two inductive couplings could be used. For example, if the surgical instrument **10** had numerous complex mechanical joints where it would be difficult to maintain a direct wired connection, inductive couplings could be used to span each such joint. For example, inductive couplers could be used on both sides of the rotary joint **29** and both sides of the articulation pivot **14**, with the inductive element **321** on the distal side of the rotary joint **29** connected by a wire **322** to the inductive element **324** of the proximate side of the articulation pivot, and a wire **323** connecting the inductive elements **325**, **326** on the distal side of the articulation pivot **14** as shown in FIG. **14**. In this embodiment, the inductive element **326** may communicate with the sensor transponder **368**.

In addition, the transponder **368** may include a number of different sensors. For example, it may include an array of sensors. Further, the end effector **12** could include a number of sensor transponders **368** in communication with the distal inductive element **324** (and hence the control unit **300**). Also, the inductive elements **320**, **324** may or may not include ferrite cores. As mentioned before, they are also preferably insulated from the electrically conductive outer shaft (or frame) of the instrument **10** (e.g., the closure tubes **40**, **42**), and the wire **322** is also preferably insulated from the outer shaft **8**.

FIG. **15** is a diagram of an end effector **12** including a transponder **368** held or embedded in the cartridge **34** at the distal end of the channel **22**. The transponder **368** may be connected to the cartridge **34** by a suitable bonding material, such as epoxy. In this embodiment, the transponder **368** includes a magnetoresistive sensor. The anvil **24** also includes a permanent magnet **369** at its distal end and generally facing the transponder **368**. The end effector **12** also includes a permanent magnet **370** connected to the sled **33** in this example embodiment. This allows the transponder **368** to detect both opening/closing of the end effector **12** (due to the permanent magnet **369** moving further or closer to the transponder as the anvil **24** opens and closes) and completion of the stapling/cutting operation (due to the permanent magnet **370** moving toward the transponder **368** as the sled **33** traverses the channel **22** as part of the cutting operation).

FIG. **15** also shows the staples **380** and the staple drivers **382** of the staple cartridge **34**. As explained previously, according to various embodiments, when the sled **33** traverses the channel **22**, the sled **33** drives the staple drivers **382** which drive the staples **380** into the severed tissue held in the end effector **12**, the staples **380** being formed against the anvil **24**. As noted above, such a surgical cutting and fastening instrument is but one type of surgical instrument in which the present invention may be advantageously employed. Various embodiments of the present invention may be used in any type of surgical instrument having one or more sensor transponders.

In the embodiments described above, the battery **64** powers (at least partially) the firing operation of the instrument **10**. As such, the instrument may be a so-called "power-assist" device. More details and additional embodiments of power-assist devices are described in the '573 application, which is incorporated herein. It should be recognized, however, that the instrument **10** need not be a power-assist device and that this is merely an example of a type of device that may utilize aspects of the present invention. For example, the instrument **10** may include a user display (such as a LCD or LED display) that is powered by the battery **64** and controlled by the control unit **300**. Data from the sensor transponders **368** in the end effector **12** may be displayed on such a display.

In another embodiment, the shaft **8** of the instrument **10**, including for example, the proximate closure tube **40** and the distal closure tube **42**, may collectively serve as part of an antenna for the control unit **300** by radiating signals to the sensor transponder **368** and receiving radiated signals from the sensor transponder **368**. That way, signals to and from the remote sensor in the end effector **12** may be transmitted via the shaft **8** of the instrument **10**.

The proximate closure tube **40** may be grounded at its proximate end by the exterior lower and upper side pieces **59**-**62**, which may be made of a nonelectrically conductive material, such as plastic. The drive shaft assembly components (including the main drive shaft **48** and secondary drive shaft **50**) inside the proximate and distal closure tubes **40**, **42** may also be made of a nonelectrically conductive material, such as plastic. Further, components of end effector **12** (such as the anvil **24** and the channel **22**) may be electrically coupled to (or in direct or indirect electrical contact with) the distal closure tube **42** such that they may also serve as part of the antenna. Further, the sensor transponder **368** could be positioned such that it is electrically insulated from the components of the shaft **8** and end effector **12** serving as the antenna. For example, the sensor transponder **368** may be positioned in the cartridge **34**, which may be made of a nonelectrically conductive material, such as plastic. Because the distal end of the shaft **8** (such as the distal end of the distal closure tube **42**) and the portions of the end effector **12** serving as the antenna may be relatively close in distance to the sensor **368**, the power for the transmitted signals may be held at low levels, thereby minimizing or reducing interference with other systems in the use environment of the instrument **10**.

In such an embodiment, as shown in FIG. **16**, the control unit **300** may be electrically coupled to the shaft **8** of the instrument **10**, such as to the proximate closure tube **40**, by a conductive link **400** (e.g., a wire). Portions of the outer shaft **8**, such as the closure tubes **40**, **42**, may therefore act as part of an antenna for the control unit **300** by radiating signals to the sensor **368** and receiving radiated signals from the sensor **368**. Input signals received by the control unit **300** may be demodulated by the demodulator **310** and decoded by the decoder **312** (see FIG. **12**). The input signals may comprise data from the sensors **368** in the end effector **12**, which the processor **306** may use to control various aspects of the instrument **10**, such as the motor **65** or a user display.

To transmit data signals to or from the sensors **368** in the end effector **12**, the link **400** may connect the control unit **300** to components of the shaft **8** of the instrument **10**, such as the proximate closure tube **40**, which may be electrically connected to the distal closure tube **42**. The distal closure tube **42** is preferably electrically insulated from the remote sensor **368**, which may be positioned in the plastic cartridge **34** (see FIG. **3**). As mentioned before, components of the end effector **12**, such as the channel **22** and the anvil **24** (see FIG. **3**), may be conductive and in electrical contact with the distal closure tube **42** such that they, too, may serve as part of the antenna.

With the shaft **8** acting as the antenna for the control unit **300**, the control unit **300** can communicate with the sensor **368** in the end effector **12** without a direct wired connection. In addition, because the distances between shaft **8** and the remote sensor **368** is fixed and known, the power levels could be optimized for low levels to thereby minimize interference with other systems in the use environment of the instrument **10**. The sensor **368** may include communication circuitry for radiating signals to the control unit **300** and for receiving signals from the control unit **300**, as described above. The communication circuitry may be integrated with the sensor **368**.

In another embodiment, the components of the shaft **8** and/or the end effector **12** may serve as an antenna for the remote sensor **368**. In such an embodiment, the remote sensor **368** is electrically connected to the shaft (such as to distal closure tube **42**, which may be electrically connected to the proximate closure tube **40**) and the control unit **300** is insulated from the shaft **8**. For example, the sensor **368** could be connected to a conductive component of the end effector **12** (such as the channel **22**), which in turn may be connected to conductive components of the shaft (e.g., the closure tubes **40**, **42**). Alternatively, the end effector **12** may include a wire (not shown) that connects the remote sensor **368** the distal closure tube **42**.

Typically, surgical instruments, such as the instrument **10**, are cleaned and sterilized prior to use. In one sterilization technique, the instrument **10** is placed in a closed and sealed container **280**, such as a plastic or TYVEK container or bag, as shown in FIGS. **17** and **18**. The container and the instrument are then placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument **10** and in the container **280**. The sterilized instrument **10** can then be stored in the sterile container **280**. The sealed, sterile container **280** keeps the instrument **10** sterile until it is opened in a medical facility or some other use environment. Instead of radiation, other means of sterilizing the instrument **10** may be used, such as ethylene oxide or steam.

When radiation, such as gamma radiation, is used to sterilize the instrument **10**, components of the control unit **300**, particularly the memory **308** and the processor **306**, may be damaged and become unstable. Thus, according to various embodiments of the present invention, the control unit **300** may be programmed after packaging and sterilization of the instrument **10**.

As shown in FIG. **17**, a remote programming device **320**, which may be a handheld device, may be brought into wireless communication with the control unit **300**. The remote programming device **320** may emit wireless signals that are received by the control unit **300** to program the control unit **300** and to power the control unit **300** during the programming operation. That way, the battery **64** does not need to power the control unit **300** during the programming operation. According to various embodiments, the programming code downloaded to the control unit **300** could be of relatively small size, such as 1 MB or less, so that a communications protocol with a relatively low data transmission rate could be used if desired. Also, the remote programming unit **320** could be brought into close physical proximity with the surgical instrument **10** so that a low power signal could be used.

Referring back to FIG. **19**, the control unit **300** may comprise an inductive coil **402** to pick up wireless signals from a remote programming device **320**. A portion of the received signal may be used by a power circuit **404** to power the control unit **300** when it is not being powered by the battery **64**.

Input signals received by the coil **402** acting as a receiving antenna may be demodulated by a demodulator **410** and decoded by a decoder **412**. The input signals may comprise programming instructions (e.g., code), which may be stored in a non-volatile memory portion of the memory **308**. The processor **306** may execute the code when the instrument **10** is in operation. For example, the code may cause the processor **306** to output control signals to various sub-systems of the instrument **10**, such as the motor **65**, based on data received from the sensors **368**.

The control unit **300** may also comprise a non-volatile memory unit **414** that comprises boot sequence code for execution by the processor **306**. When the control unit **300** receives enough power from the signals from the remote control unit **320** during the post-sterilization programming operation, the processor **306** may first execute the boot sequence code ("boot loader") **414**, which may load the processor **306** with an operating system.

The control unit **300** may also send signals back to the remote programming unit **320**, such as acknowledgement and handshake signals, for example. The control unit **300** may comprise an encoder **416** for encoding the signals to then be sent to the programming device **320** and a modulator **418** for modulating the signals according to the modulation scheme. The coil **402** may act as the transmitting antenna. The control unit **300** and the remote programming device **320** may communicate using any suitable wireless communication protocol (e.g., Bluetooth) and any suitable frequency (e.g., an ISM band). Also, the control unit **300** may transmit signals at a different frequency range than the frequency range of the received signals from the remote programming unit **320**.

FIG. **20** is a simplified diagram of the remote programming device **320** according to various embodiments of the present invention. As shown in FIG. **20**, the remote programming unit **320** may comprise a main control board **230** and a boosted antenna board **232**. The main control board **230** may comprise a controller **234**, a power module **236**, and a memory **238**. The memory **238** may stored the operating instructions for the controller **234** as well as the programming instructions to be transmitted to the control unit **300** of the surgical instrument **10**. The power module **236** may provide a stable DC voltage for the components of the remote programming device **320** from an internal battery (not shown) or an external AC or DC power source (not shown).

The boosted antenna board **232** may comprise a coupler circuit **240** that is in communication with the controller **234** via an I^2C bus, for example. The coupler circuit **240** may communicate with the control unit **300** of the surgical instrument via an antenna **244**. The coupler circuit **240** may handle the modulating/demodulating and encoding/decoding operations for transmissions with the control unit. According to other embodiments, the remote programming device **320** could have a discrete modulator, demodulator, encoder and decoder. As shown in FIG. **20**, the boost antenna board **232** may also comprise a transmitting power amp **246**, a matching circuit **248** for the antenna **244**, and a filter/amplifier **249** for receiving signals.

According to other embodiments, as shown in FIG. **20**, the remote programming device could be in communication with a computer device **460**, such as a PC or a laptop, via a USB and/or RS232 interface, for example. In such a configuration, a memory of the computing device **460** may store the programming instructions to be transmitted to the control unit **300**. In another embodiment, the computing device **460** could be configured with a wireless transmission system to transmit the programming instructions to the control unit **300**.

In addition, according to other embodiments, rather than using inductive coupling between the control unit **300** and the remote programming device **320**, capacitively coupling could be used. In such an embodiment, the control unit **300** could have a plate instead of a coil, as could the remote programming unit **320**.

In another embodiment, rather than using a wireless communication link between the control unit **300** and the remote programming device **320**, the programming device **320** may be physically connected to the control unit **300** while the instrument **10** is in its sterile container **280** in such a way that the instrument **10** remains sterilized. FIG. **21** is a diagram of a packaged instrument **10** according to such an embodiment. As shown in FIG. **22**, the handle **6** of the instrument **10** may include an external connection interface **470**. The container **280** may further comprise a connection interface **472** that mates with the external connection interface **470** of the instrument **10** when the instrument **10** is packaged in the container **280**. The programming device **320** may include an external connection interface (not shown) that may connect to the connection interface **472** at the exterior of the container **280** to thereby provide a wired connection between the programming device **320** and the external connection interface **470** of the instrument **10**.

The various embodiments of the present invention have been described above in connection with cutting-type surgical instruments. It should be noted, however, that in other embodiments, the inventive surgical instrument disclosed herein need not be a cutting-type surgical instrument, but rather could be used in any type of surgical instrument including remote sensor transponders. For example, it could be a non-cutting endoscopic instrument, a grasper, a stapler, a clip applier, an access device, a drug/gene therapy delivery device, an energy device using ultrasound, RF, laser, etc. In addition, the present invention may be in laparoscopic instruments, for example. The present invention also has application in conventional endoscopic and open surgical instrumentation as well as robotic-assisted surgery.

The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

Although the present invention has been described herein in connection with certain disclosed embodiments, many modifications and variations to those embodiments may be implemented. For example, different types of end effectors may be employed. Also, where materials are disclosed for certain components, other materials may be used. The foregoing description and following claims are intended to cover all such modification and variations.

Any patent, publication, or other disclosure material, in whole or in part, that is said to be incorporated by reference herein is incorporated herein only to the extent that the incorporated materials does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

What is claimed is:

1. A surgical instrument comprising:
- an end effector comprising at least one sensor;
- a shaft having a distal end connected to the end effector, wherein the shaft comprises:
  - at least one electrically conductive outer tube, wherein the sensor is electrically insulated from the at least one electrically conductive outer tube; and
  - a drive shaft disposed at least partially within the at least one electrically conductive outer tube;
- a handle connected to a proximate end of the shaft, the handle housing a control unit, wherein the control unit is electrically coupled to the at least one electrically conductive outer tube such that the at least one electrically conductive outer tube wirelessly radiates communication signals from the control unit to the sensor and receives wirelessly radiated communication signals from the sensor.

2. The surgical instrument of claim **1**, wherein the handle further houses:
- a motor in communication with the control unit and for powering the end effector; and
- a battery for powering the motor.

3. The surgical instrument of claim **1**, wherein the at least one sensor comprises a magnetoresistive sensor.

4. The surgical instrument of claim **1**, wherein the at least one sensor comprises a pressure sensor.

5. The surgical instrument of claim **1**, wherein the at least one sensor comprises a RFID sensor.

6. The surgical instrument of claim **1**, wherein the at least one sensor comprises a MEMS sensor.

7. The surgical instrument of claim **1**, wherein the at least one sensor comprises an electromechanical sensor.

8. The surgical instrument of claim **1**, wherein the at least one sensor is connected to a plastic cartridge of the end effector.

9. The surgical instrument of claim **1**, wherein the end effector comprises an electrically conductive component coupled to the at least one electrically conductive outer tube, wherein the electrically conductive component is configured to radiate communication signals to and from the sensor.

10. The surgical instrument of claim **1**, wherein the surgical instrument comprises an endoscopic surgical instrument.

11. The surgical instrument of claim **1**, wherein the surgical instrument comprises a cutting and fastening surgical instrument.

12. The surgical instrument of claim **11**, wherein the end effector comprises a cutting instrument.

13. The surgical instrument of claim **12**, wherein the end effector comprises a plastic cartridge and the at least one sensor is disposed in the cartridge.

14. The surgical instrument of claim **1**, wherein the communication signals radiated wirelessly from the shaft use a wireless communication protocol.

15. The surgical instrument of claim **1**, wherein the wireless signals comprise RF wireless signals.

16. A surgical instrument comprising:
- an end effector comprising at least one sensor;
- an electrically conductive shaft having a distal end connected to the end effector wherein the shaft comprises at least one electrically conductive outer tube, wherein the sensor is electrically insulated from the at least one electrically conductive outer tube; and
- a control unit electrically coupled to the shaft such that the at least one electrically conductive outer tube wirelessly radiates communication signals from the control unit to the sensor and to receives wirelessly radiated communication signals from the sensor.

17. The surgical instrument of claim **16**, further comprising:
- a motor in communication with the control unit and for powering the end effector; and
- a battery for powering the motor.

18. The surgical instrument of claim **16**, wherein the at least one sensor is connected to a plastic cartridge of the end effector.

19. The surgical instrument of claim **16**, wherein the end effector comprises an electrically conductive component coupled to the at least one electrically conductive outer tube, wherein the electrically conductive component is configured to radiate wireless communication signals to and from the sensor.

20. The surgical instrument of claim **19**, wherein the end effector comprises a plastic staple cartridge and the at least one sensor is disposed in the staple cartridge.

21. A surgical instrument comprising:
- an end effector comprising at least one sensor;
- an electrically conductive shaft having a distal end connected to the end effector, wherein the shaft comprises at least one electrically conductive outer tube, wherein the sensor is electrically coupled to the at least one electrically conductive outer tube; and
- a control unit electrically insulated from the at least one electrically conductive outer tube, such that the at least one electrically conductive outer tube radiates wireless communication signals from the sensor to the control unit and receives wirelessly radiated communication signals from the control unit.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,459,520 B2
APPLICATION NO. : 11/651807
DATED : June 11, 2013
INVENTOR(S) : James R. Giordano et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1106 days.

Signed and Sealed this
Twenty-third Day of December, 2014

Michelle K. Lee

Michelle K. Lee
Deputy Director of the United States Patent and Trademark Office